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BULLETIN

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CONTRIBUTION TO THE HERPETOLOG OF THE SMOKY MOUNTAINS OF TENNES

WALTER L. NECKER

The Great Smoky Mountains of North Carolina and Tennessee have become well-known to herpetologists during the past score of years, because of their most interesting salamander fauna. In spite of all the work on these animals, only a casual mention of the remainder of the herpetofauna can be found in the literature. It therefore seems justifiable to report on the reptiles and salientians in several small collections which are available to me, even though I am aware that the list is necessarily incomplete. The salamanders are not treated because the material is not sufficient to warrant description in view of previous work. *Triturus viridescens*, collected at Cades Cove, 2000 feet altitude, May 1, 1933, is the only species not previously reported from these mountains.

The paper is based on collections made by Edwin V. Komarek, Donald C. Lowrie, and Walter L. Necker during April, 1931; by Vera Y. Foster during the last week of April, 1932; and by Edwin V. and Roy V. Komarek at intervals during 1932 and 1933. The first two were made in the vicinity of Greenbrier, Sevier County, Tennessee, under the auspices of the Chicago Academy of Sciences; the other partly at Greenbrier, and partly at Cades Cove, Blount County, Tennessee, during a preliminary survey of the mammal life of the Smoky Mountains, being conducted by Mr. Komarek for the Academy. Several specimens collected by A. S. Windsor near Gatlinburg, Sevier County, Tennessee, are also included.

I am indebted to the Director of the Academy, Mr. Alfred M. Bailey, for the privilege of reporting on the collections in the Academy, and, especially, to Mr. Karl P. Schmidt for the use of specimens in the collection of Field Museum of Natural History, as well as for many helpful suggestions during the preparation of the manuscript.

The colloquial name follows the scientific. Museum numbers are given for all snakes (C.A.S. for the Chicago Academy of Sciences and F.M. for Field Museum of Natural History); they are omitted for the other forms, as no data for individuals is given. Representatives of nearly all series have been deposited in Field Museum, the main series being kept in the museum of the Academy.

Bufo americanus americanus HOLBROOK — Toad-frog

Toads are very common in the low, marshy meadows. Breeding activities were in full swing during the third week in April, 1931. 30 specimens, Greenbrier, 17-1800 feet, March and April, 1931 and 1932.

Pseudacris nigrita triseriata (WIED)

Found in marshy meadows and springs; confined to lower altitudes. 13 from Greenbrier, 1600 feet, March 24, 1932; 3 from Greenbrier, 1700 feet, November 19, 1932; 3 from Cades Cove, 2000 feet, May 1, 1933.

Hyla crucifer WIED

Found in the same habitat as *Pseudacris*, but much more abundant. 32 from Greenbrier, 1700 feet, March 19, 1931; 1, Greenbrier, 1700 feet, November 19, 1932; 19, Cades Cove, 2000 feet, May 1, 1933; 42, Cades Cove, 2000 feet, May 4, 1933 (including one albino).

Hyla versicolor versicolor LECONTE

20 specimens from Cades Cove, 2000 feet, May 1, 1933; and 1 from Dry Valley, near Cades Cove, 1700 feet, May, 1933.

Rana catesbeiana SHAW — Bull-frog

Rare near marshes and ponds of the lower altitudes. Two from Greenbrier, 1700 feet, April 29, 1932 and April 26, 1933.

Rana clamitans LATREILLE — Little bull-frog

The commonest of the true frogs, frequenting the slower streams as well as marshy localities. 7 from Greenbrier, 16-1800 feet, March and April, 1931 to 1933; 7 from Cades Cove, 1900-2000 feet, May 1-4, 1933.

Rana pipiens SCHREBER

Only one specimen collected. Cades Cove, 2000 feet, May 4, 1933.

Sceloporus undulatus (LATREILLE) — Fence lizard

Very common from 1700-2900 feet altitude; frequents rail and stone fences and open rocky places. 23 specimens from Greenbrier, 1700-2900 feet, March and April, 1931-1933; 1 from Cades Cove, 2000 feet, April 30, 1933.

Eumeces fasciatus (LINNAEUS) — Scorpion

Much scarcer than *Sceloporus*. One lived under our cabin; others were frequently seen on a log bridge over a fork of the Little Pigeon River near Greenbrier. The series is too small to allow an opinion on the recent splitting of this species by Taylor. 3 from Greenbrier, April 26-29, 1932; 1, Greenbrier, February, 1933 (excavated by a road-building gang); 1, Greenbrier, March 18, 1933.

Carphophis amoena amoena (SAY)

The single specimen appears to be *amoena*, in that the prefrontals and internasals are not united; the ventrals, also, are above the average given by Blanchard* for *helenae*. A series will very likely show

*The forms of Carphophis. Papers Mich. Acad. Sci., 4, 527-530, 1925.

that the form found in these mountains is intermediate. Supralabials, 5; infralabials, 6; oculars, 1-1; temporals, 1-2.

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	1783	Greenbrier	August, 1932	♀	13-13-13	131	32	213	15

Diadophis punctatus edwardsii (MERREM) Young black snake

Common under rotting logs. The mountaineers insist that this is the young of *Elaphe obsoleta.* Supralabials, 8; infralabials, 8; oculars, 1-2; temporals 1-1, except in C.A.S. 1315 where they are 1-2.

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	1099	Greenbrier	Apr. 26, 1932	♂	15-15-15	162	61	158	20
C.A.S.	1780	Greenbrier	July, 1932	♀	15-15-15	154	49	148	19
C.A.S.	1781	Greenbrier, 1800 ft.	Mar. 18, 1932	♂	15-15-15	158	57	337	22
C.A.S.	1782	Greenbrier	August, 1932	♂	15-15-15	157	58	365	22
F.M.	19304	Greenbrier	April, 1931	♂	15-15-15	162	58	384	22

Opheodrys aestivus (LINNAEUS)

Supralabials, 7, except C.A.S. 1779 which has 6 on one side; infralabials, 8, except C.A.S. 1779 which has 7 on one side; oculars, 1-2, except F.M. 15810 which has 2-2 on both sides; temporals, 1-2.

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	1779	Greenbrier	Jul. 6, 1932	♂	17-17-15	161	133	288	35
F.M.	15810	Gatlinburg	Jul. 5, 1931	♂	17-17-15	155	132	610	40
F.M.	15911	Gatlinburg	Jul. 9, 1931	♀	17-17-15	153	129	698	38

Coluber constrictor constrictor (LINNAEUS) Racer

Supralabials, 7 and 8; infralabials, 9; oculars, 1-2 and 2-2; temporals, 2-2.

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	1760	Greenbrier	August, 1932	♂	22-17-15	179	97	924	26

Elaphe obsoleta obsoleta (SAY) Black snake

This species is more common than the one specimen collected would indicate. Supralabials, 8; infralabials, 11; oculars, 1-2; temporals, 2-3 and 3-3.

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	872	Greenbrier	Apr. 10, 1931	♀	25-25-19	234	72		

Lampropeltis triangulum triangulum (LACEPEDE) House snake

Supralabials, 7; infralabials, 9; oculars, 1-2; temporals, 2-3, except in F.M. 19306, which has 2-2 on one side.

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	1609	Greenbrier	August, 1932	♀	21-21-17	206	44		
C.A.S.	1761	Greenbrier, 1760 ft.	Mar. 21, 1933	♂	21-21-19	197	48	730	16
C.A.S.	1762	Greenbrier, 1760 ft.	Mar. 20, 1933	♂	21-21-19	194	48	577	15
C.A.S.	1763	Greenbrier, 1760 ft.	Mar. 7, 1933	♂	21-21-19	198	48	833	13
F.M.	19306	Greenbrier	Jul. 6, 1932	♂	21-21-19	205	47	288	14

Natrix sipedon sipedon (LINNAEUS) Water snake

Very abundant along all streams. Supralabials, 8, except in C.A.S. nos. 870 and 1341 which have 9 on one side; infralabials, 10, except in C.A.S. nos. 870 and 1770 which have 11 on one side, 1336, 1342, and 1769 which have 11 on both sides, and 1339 which has 9 on both sides; oculars, 1-3, except C.A.S. nos. 1335 and 1770, which have

1-2 on one side, and 1339 which has 1-2 on both sides; temporals, 1-3, except C.A.S. nos. 870, 871, 1336, and 1769, and F.M. 19307, which have 1-2 on one side, and C.A.S. nos. 1335, 1311, and 1610 which have 1-2 on both sides

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	870	Greenbrier, 1800 ft.	Apr. 12, 1931	♀	21-23-17	136	60	271	23
C.A.S.	871	Greenbrier, 2000 ft.	Apr. 26, 1932	♂	21-23-17	132	77	725	26
C.A.S.	1335	Greenbrier	Apr. 26, 1932	♀	21-23-19	138			
C.A.S.	1336	Greenbrier	Apr. 18, 1931	♀	23-21-17	139			
C.A.S.	1337	Greenbrier	Apr. 26, 1932	♂	23-23-17	135	68	229	26
C.A.S.	1338	Greenbrier	Apr. 26, 1932	♂	21-23-17	135	69	223	26
C.A.S.	1339	Greenbrier	Apr. 26, 1932	♂	23-23-17	137	74	210	27
C.A.S.	1340	Greenbrier	Apr. 26, 1932	♂	21-23-17	138			
C.A.S.	1341	Greenbrier	Apr. 26, 1932	♀	23-23-17	132	62	274	23
C.A.S.	1342	Greenbrier	Apr. 26, 1932	♂	21-23-19	138			
C.A.S.	1610	Greenbrier	August, 1932	♀	23-23-19	138	56	777	21
C.A.S.	1769	Greenbrier, 3000 ft.	Jul. 17, 1932	♀	21-19-17	138	67	614	22
C.A.S.	1770	Greenbrier	August, 1932	♂	21-21-17	137	73	626	27
F.M.	19307	Greenbrier, 1650 ft.	Mar. 24, 1933	♂	21-23-17	133	77	221	27

Thamnophis sirtalis sirtalis (LINNAEUS) Garter snake

Garter snakes are common throughout the mountains and are worthy of considerable study. Supralabials, 7, except C.A.S. nos. 1767 and 1768, which have 8; infralabials, 10, except C.A.S. nos. 1764 and 1766 which have 9 on one side, and 1765 which has 9 on both sides; oculars, 1-3, except C.A.S. nos. 1343 and 1344, and F.M. 19302 which have 1-4 on one side, and C.A.S. 1764 which has 2-2 on one side; temporals, 1-2, except F. M. 19302, which has 1-3 on one side, and C.A.S. nos. 1343 and 1314 which have 1-3 on both sides.

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	901	Greenbrier	Apr. 24, 1931	♀	19-19-17	147	65	618	22
C.A.S.	902	Greenbrier	Apr. 24, 1931	♀	19-19-17	143	66	654	22
C.A.S.	1343	Greenbrier, 4000 ft.	Apr. 26, 1932	♀	19-19-17	143	65	680	21
C.A.S.	1344	Greenbrier, 4000 ft.	Apr. 26, 1932	♀	19-19-17	145	67	620	22
C.A.S.	1764	Greenbrier, 1800 ft.	Feb. 1, 1933	♂	19-19-17	151	76	553	25
C.A.S.	1765	Greenbrier, 6400 ft.	Jun. 20, 1933	♀	19-19-17	144	57	518	20
C.A.S.	1766	Greenbrier, 5000 ft.	Jun. 18, 1933	♀	19-19-17	145	63	622	19
C.A.S.	1767	Greenbrier, 2500 ft.	Sep. 30, 1933	♀	19-19-17	146	61	554	20
C.A.S.	1768	Greenbrier, 5200 ft.	Sep. 30, 1922	♂	19-19-17	146	69	950	23
F.M.	19308	Greenbrier, 1800 ft.	Mar. 18, 1932	♂	19-19-17	155	74	274	23
F.M.	19303	Greenbrier, 4500 ft.	April, 1931	♀	19-19-17	146	67		
F.M.	19302	Greenbrier, 1750 ft.	Apr. 8, 1931	♂	19-19-17	153	78	590	26

Agkistrodon mokasen BEAUVOIS Copperhead

Supralabials, 8; infralabials, 10 and 11; oculars, 2-4 and 2-5.

Mus.	No.	Locality	Date	Sex	Rows	vntrls	cdls	lgth	%t'l
C.A.S.	1603	Greenbrier	August, 1932	♂	25-21-17	150	48	774	14

Crotalus horridus LINNAEUS Rattler

One specimen, beyond preservation, was received, and several skins were seen.

Chelydra serpentina (LINNAEUS) Snapper

A specimen with carapace measurement of 10 inches, was found about 1800 feet, at Greenbrier, April, 1931.

Terrapene carolina (LINNAEUS)

One collected near Greenbrier, 1000 feet, November, 1932.

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BULLETIN

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SUPPLEMENT TO AN ANNOTATED FLORA OF THE CHICAGO AREA BY H. S. PEPOON

CARL A. BUHL

Numerous articles and much additional information accumulated since the appearance of *An Annotated Flora of the Chicago Area* by Dr. H. S. Pepoon, call for a supplement to the orginal work that it may remain of the greatest possible value. All authentic additions to the flora and all records of plants orginally included in the flora that, because of changes in nomenclature or incorrect identification of specimens, become equivalent to a valid form, are recorded. Several apparently overlooked published records of plants are omitted as they are rare escapes from cultivation, unestablished foreign adventives, or equivalents of an included form. Further work is in many cases necessary to determine the valid inclusion in the flora of certain foreign adventives. Forms have not been deleted from the flora merely because they are rare adventives or escapes from cultivation with only one or two records to their credit although in any future enumeration of the flora this fact should be more clearly indicated. Reference is usually made to the first published report although occurrence may have been verified from unpublished records. For Deam's reports, however, the latest editions of his works on the trees and shrubs of Indiana have been cited as they are the most detailed and accurate.

Changes due merely to revised nomenclatorial concepts are not included.

For botanical purposes the Chicago Area is extended to include all of Cook, DuPage, and Lake Counties, Illinois and Lake and Porter Counties, Indiana, for the slight increase in species thus occasioned is far offset by the easier ascertainment of the limits of the region.

I am much indebted to Mr. A. M. Bailey, Mr. C. C. Deam, Dr. N. C. Fassett, Dr. J. M. Greenman, Dr. Theodor Just, Dr. M. W. Lyon, Dr. W. T. McLaughlin, Dr. B. L. Robinson, Dr. P. C. Standley, and Dr. L. R. Tehon for use of and information concerning the specimens in the herbaria under their supervision; and especially to Mr. C. C. Deam and Dr. H. S. Pepoon for reading the manuscript and offering many helpful suggestions, and to Mr. D. C. Peattie for much information concerning reports in his flora of the dune region.

ADDITIONS TO THE FLORA OF THE CHICAGO AREA

Equisetum kansanum Schaffner. Porter Co. Ind. (Deam no. 20,062)
Equisetum nelsoni (Eaton) Schaffner. Lake Co. Ind. (Deam, 1928)
Lycopodium tristachyum Pursh. Lake and Porter Cos. Ind. (Peattie, 1930)
Typha angustifolia var. *calumetensis* Peattie. Lake Co. Ind. (Peattie, 1926)
Sparganium chlorocarpum Rydberg. Lake Co. Ind. (Deam herb.: Umbach specimen).
Potamogeton crispus Linnaeus. Cook Co. Ill. (Hull, 1913)
Potamogeton praelongus Wulf. Lake Co. Ind. (Hill, 1885)
Najas flexilis var. *robusta* Morong. Lake Co. Ind. (Peattie, 1930)
Najas guadelupensis (Sprengel) Morong. Cook Co. Ill. (Peattie, 1930)
Elodea nuttallii (Planchon) St. John. Cook Co. Ill. (Peattie, 1930)
Paspalum ciliatifolium var. *stramineum* (Nash) Fernald. Lake Co. Ind. (Deam, 1929, as *P. stramineum*)
Panicum addisonii Nash. Porter Co. Ind. (Lyon, 1927 as *P. mattamuskeetense*)
Panicum auburne Ashe. Porter Co. Ind (Hill, 1915)
Panicum commutatum var. *ashei* (Pearson) Fernald. Porter Co. Ind. (Hill, 1915, as *P. ashei*)
Panicum deamii Hitchcock & Chase. Lake Co. Ind. (Deam, 1929)
Panicum lanuginosum var. *septentrionalis* Fernald. Lake Co. Ind. (Deam, 1929, as *P. lindheimeri* var. *septentrionalis*)
Panicum meridionale var. *albemarlense* (Ashe) Fernald. Porter Co. Ind. (Hill, 1915, as *P. albemarlense*)
Panicum villosissimum var. *pseudopubescens* (Nash) Fernald. Porter Co. Ind. (Lyon, 1927, as *P. pseudopubescens*)
Zizania aequatica var. *angustifolia* Hitchcock. Lake Co. Ind. (Peattie, 1930)
Zizania aequatica var. *interior* Fassett. Lake Co. Ind. (Peattie, 1930)
Milium effusum Linnaeus. Porter Co. Ind. (Peattie, 1930)
Oryzopsis asperifolia Michaux. Lake and Porter Cos. Ind. (Deam, 1929)
Oryzopsis pungens (Torrey) Hitchcock. Porter Co. Ind. (Lyon, 1927)
Muhlenbergia foliosa (R. & S.) Trinius. Lake and Porter Cos. Ind. (Deam, 1929)
Bromus altissimus Pursh. Porter Co. Ind. (Peattie, 1930)
Elymus riparius Wiegand. Porter Co. Ind. (Peattie, 1930)
Elymus virginicus var. *jejunis* (Romaley) Bush. Lake Co. Ind. (Deam, 1905, as *E. glaucus*)
Elymus virginicus var. *submuticus* Hooker. Lake Co. Ind. (Deam, 1929)
Cyperus flavescens Linnaeus. Cook Co. Ill (Higley & Raddin, 1891)
Cyperus strigosus var. *robustior* Kunth. Porter Co. Ind. (Peattie, 1930)
Eleocharis smallii Britton. Lake Co. Ind. (Deam, 1930)
Scirpus eriophorum Michaux. Lake and Porter Cos. Ind. (Peattie, 1930)
Scirpus pedicellatus Fernald. Lake Co. Ind. (Deam no. 50,562)
Scirpus rubrotinctus Fernald. Lake Co. Ill. (Gates, 1909)
Scirpus smithii var. *setosa* Fernald. Porter Co. Ind. (Lyon, 1927)
Eriophorum angustifolium Roth. Lake Co. Ill. (Gates, 1909)
Carex deflexa Hornemann. Lake Co. Ind. (Peattie, 1930)
Carex glaucodea Tuckerman. Lake Co. Ind. (Peattie, 1930)
Carex hassei Bailey. Lake Co. Ind. (Deam, 1928)
Carex laxiculmis Schweinitz. Porter Co. Ind. (Lyon, 1927)
Carex ormostachya Wiegand. Porter Co. Ind. (Deam, 1928)
Carex prairea Dewey. Lake Co. Ind. (Peattie, 1930)
Carex rugosperma Mackensie. Lake Co. Ind. (Deam, 1928)

Carex schriveri Britton. Lake Co. Ind. (Herman no. 1040)
Carex strictior Dewey. Porter Co. Ind. (Deam, 1928)
Carex swanii (Fernald) Mackensie. Porter Co. Ind. (Lyon, 1927)
Carex tonsa (Fernald) Bicknell. Porter Co. Ind. (Deam, 1917)
Carex vesicaria var. *monile* (Tuckerman) Fernald. Lake Co. Ind. (Peattie, 1930)
Carex woodii Dewey. Porter Co. Ind. (Deam no. 40,440)
Commelina angustifolia Michaux. Porter Co. Ind. (Deam, 1917)
Commelina communis var. *verticillata* Peattie. Lake Co. Ind. (Peattie, 1926)
Juncus effusus var. *pylaei* (Laharpe) Fernald & Wiegand. Lake and Porter Cos. Ind. (Univ. Wisc. Herb.: Umbach specimens)
Juncus gerardii Loisel. Lake Co. Ind. (Higley & Raddin, 1891)
Juncus interior Wiegand. Lake Co. Ind. (Peattie, 1930)
Juncus scirpoides Lamarck. Lake Co. Ind. (Hill, 1899)
Juncus tenuis var. *anthelatus* Wiegand. Lake and Porter Cos. Ind. (Peattie, 1930)
Allium stellatum Ker. Porter Co. Ind. (Standley, 1932)
Maianthemum canadense var. *interius* Fernald. Lake and Porter Cos. Ind. (Deam, 1926)
Sisyrinchium atlanticum Bicknell. Lake and Porter Cos. Ind. (Deam, 1922)
Spiranthes lucida (Eaton) Ames. Lake Co. Ind. (Field Museum herb. no. 718,743)
Corallorrhiza odontorhiza Nuttall. Porter Co. Ind. (Deam no. 17,993)
Salix lucida var. *intonsa* Fernald. Lake Co. Ind. (Peattie, 1930)
Ostrya virginiana var. *glandulosa* Sargent. Lake and Porter Cos. Ind. (Deam, 1931a)
Betula nigra Linnaeus. Lake and Porter Cos. Ind. (Deam, 1931a)
Alnus rugosa (Du Roi) Sprengel. Lake and Porter Cos. Ind. (Deam, 1932)
Pilea fontana (Lunell) Rydberg. Porter Co. Ind. (Lyon, 1928, as *Adicea fontana*)
Boehmeria cylindrica var. *drummondii* Weddell. Porter Co. Ind. (Lyon, 1927 as *B. c.* var. *scabra*)
Rumex mexicanus Meisner. Cook Co. Ill. (Field Museum: H. H. Smith nos. 5647, 5933, & 5949 and Lansing nos. 442, 1414, 1352.)
Chenopodium bushianum Aellen. Lake and Porter Cos. Ind. (Deam, 1931)
Chenopodium lanceolatum Muhlenberg. Porter Co. Ind. (Deam no. 39,737)
Atriplex patula var. *littoralis* (Linnaeus) Gray. Lake and Porter Cos. (Peattie, 1930)
Corispermum nitidum Kitaidel. Porter Co. Ind. (Standley, 1932)
Stellaria graminea Linnaeus. Lake Co. Ind. (Peattie, 1930)
Stellaria longipes Goldie. Cook Co. Ill. (Higley & Raddin, 1891)
Silene csereii Baumgarten. Lake Co. Ind. (Fassett, 1934)
Silene dichotoma Ehrhart. Cook Co. Ill. (Field Museum: Calkin no. 122)
Ranunculus hispidus Michaux. Lake and Porter Cos. Ind. (Peattie, 1930)
Erucastrum pollichii S. & S. Porter Co. Ind. (Standley, 1932)
Arabis glabra (Linnaeus) Bernhardi. Porter Co. Ind. (Lyon, 1927)
Heuchera richardsonii var. *grayana* R., B., & L. Lake & Porter Cos. Ind. (Deam nos. 20,102 & 20,053)
Ribes americanum var. *mesochora* (Nwl.) Peattie. Porter Co. Ind. (Nieuwland, 1915, as *Coreosma americana* var. *mesochora*)
Crataegus spp. await an adequately rational treatment of the genus.
Rubus idaeus var. *canadensis* Richardson. Lake Co. Ind. (Deam, 1932)
Rosa lyoni Pursh. Lake Co. Ind. (Peattie, 1932)
Rosa setigera var. *tomentosa*. Cook Co. Ill. (Deam, 1932)

Prunus virginiana var *demissa* (Walpole) Torrey. Lake and Porter Cos. Ind. (Deam, 1932)
Tephrosia virginiana var. *holosericea* (Nuttall) Torrey & Gray. Porter Co. Ind. (Peattie, 1930)
Coronilla varia Linnaeus. Lake Co. Ind. (Standley, 1932)
Robinia hispida Linnaeus. Lake Co. Ind. (Hull, 1934)
Glycyrrhiza lepidota Pursh. Porter Co. Ind. (Hull, 1934a)
Desmodium rotundifolium (Michaux) DeCandolle. Cook Co. Ill. (Higley & Raddin, 1891)
Lespedeza capitata var. *longifolia* (DeCandolle) T. & G. Lake and Porter Cos. Ind. (Peattie, 1930)
Lathyrus venosus var. *intonsus* Butters & St. John. Lake and Porter Cos. Ind. (Deam, 1930)
Geranium bicknellii Britton. Lake Co. Ind. (Deam, 1921)
Euphorbia lansingii Millspaugh. Cook Co. Ill. (Field Museum: Lansing no. 204 is type specimen)
Acer negundo var. *violaceum* Kirchner Lake and Porter Cos. Ind. (Deam, 1931a)
Vitis vulpina var. *syrticola* Fernald & Wiegand. Lake and Porter Cos. Ind. (Deam, 1932)
Hypericum boreale (Britton) Bicknell. Porter Co. Ind. (Peattie, 1930)
Lechea tenuifolia Michaux. Porter Co. Ind. (Lyon, 1927)
Viola incognita var. *forbesii* Brainerd. Porter Co. Ind. (Peattie, 1930)
Decodon verticillatus var. *laevigatus* T. & G. Lake Co. Ind. (Deam, 1919)
Oenethera laciniata Hill. Porter Co. Ind. (Lyon, 1927, as *Raimannia laciniata*)
Oenethera pratensis (Small) Robinson. Porter Co. Ind. (Peattie, 1930)
Circaea alpina Linnaeus. Porter Co Ind. (Lyon, 1927)
Proserpinaca palustris var. *amblyogona* Fernald. Lake Co. Ind. (Peattie 1930)
Hippuris vulgaris Linnaeus. Lake Co. Ill. (Field Museum: Gates no. 1756)
Zizia sylvatica Benke. Cook Co. Ill. (Benke, 1932)
Styrax americana Lamarck. Lake and Porter Cos. Ind. (Deam, 1932)
Apocynum hypericifolium var. *farwellii* (Greene) Woodson. Lake Co. Ind. (Deam no. 53,924)
Asclepias meadii Torrey. Lake Co. Ind. (Brannon specimen in Deam herb.)
Cuscuta compacta Jussieu. Lake and Porter Cos. Ind. (Peattie, 1930)
Phlox taniculata Linnaeus. Porter Co. Ind. (Deam herb.)
Phlox maculata Linnaeus. Cook Co Ill. (Higley & Raddin, 1891)
Lithospermum officinale Linnaeus. Lake Co. Ill. (Gates, 1909)
Scutellaria parvula var. *ambigua* (Nuttall) Fernald. Lake Co. Ind. (Peattie, 1930)
Physostegia speciosa (Sweet). Lake Co. Ind. (Deam, 1933, as *Dracocephalum speciosum*)
Satureja vulgaris (Linnaeus) Fritsch. Porter Co. Ind. (Deam no. 8,806)
Physalis lanceolata Michaux. Cook Co. Ill. (Higley & Raddin, 1891)
Chelone glabra var. *linifolia* Coleman. Lake and Porter Cos. Ind. (Deam nos. 49,851 and 39,735)
Penstemon calycosus Small. Porter Co. Ind. (Lyon, 1927)
Penstemon digitalis (Sweet) Nuttall. Lake Co. (Deam, 1924)
Penstemon pallidus Small. Cook Co. Ill. (Field Museum: Umbach specimens originally labelled *P. hirsutus*)
Gratiola mesochora Peattie. Lake Co. Ind. (Peattie, 1926)
Veronica officinalis Linnaeus. Porter Co. Ind. (Deam no. 45,941)
Aureolaria pedicularia var. *intercedens* Pennell. Cook Co. Ill. (Field Museum herb. no. 513,717.)

Agalinis tenuifolia var. *parviflora* (Nuttall) Pennell. Porter Co. Ind. (Peattie, 1930)
Campsis radicans (Linnaeus) Seeman. Lake Co. Ind. (Deam, 1932)
Galium boreale var. *intermedium* DeCandolle. Lake Co. Ind. (Deam no. 31,606)
Galium boreale var. *hyssopifolium* (Hoffmann) DeCandolle. Lake Co. Ind. (Deam no. 50,564)
Viburnum affine var. *hypomalacum* Blake. Lake and Porter Cos. Ind. (Deam, 1932.)
Vernonia baldwini Torrey. Lake Co. Ill. (Fassett, 1933)
Mikania scandens (Linnaeus) Willdenow. Porter Co. Ind. (Deam no. 26,496)
Solidago hirtella (Greene) Bush. Porter Co. Ind. (Lyon, 1927 as *S. graminifolia* var. *nuttallii*)
Solidago longipetiolata Mackensie & Bush. Porter Co. Ind. (Friesner, 1933)
Solidago racemosa Greene. Lake and Porter Cos. Ind. (Friesner, 1933)
Solidago uniligulata var. *levipes* Fernald. Lake Co. Ind. (Friesner, 1933)
Aster ericoides var. *pringlei* Gray, Lake Co. Ind. (Peattie, 1930)
Aster exiguus (Fernald) Rydberg. Porter Co. Ind. (Deam, 1934)
Aster furcatus Burgess. Porter Co. Ind. (Peattie, 1930)
Aster interior Wiegand. Cook Co. Ill. (Field Museum: Benke nos. 5625, 5628, 5632, 5637, 5639, & 5641)
Aster missouriensis var. *thyrsoides* (Gray) Wiegand. Porter Co. Ind. (Deam no. 26,479)
Aster parviceps (Burgess) M. & B. Cook Co. Ill. (Field Museum: Gates no. 1005) Du Page Co. Ill. (Field Museum: E. C. Smith nos. 563 & 583)
Aster pilosus Willdenow. Porter Co. Ind. (Benke, 1932)
Aster puniceus var. *demissus* Lindley. Porter Co. Ind. (Peattie, 1930)
Antennaria occidentalis Greene. Lake Co. Ind. (Peattie, 1930)
Antennaria parlinii Fernald. Porter Co. Ind (Lyon, 1927)
Silphium terabinthinaceum var. *pinnatifidum* Torrey & Gray. Lake and Porter Cos. Ind. (Peattie, 1930)
Brauneria angustifolia (DeCandolle) Heller. Lake Co. Ind. (Peattie, 1933)
Madia capitata Nuttall. Porter Co. Ind. (Deam, 1930)
Helianthus ambiguus (Gray) Britton. Lake Co. Ind. (Deam 42,284) Cook Co. Ill. (Field Museum herb. no. 68,144)
Helianthus arenicola Watson. Lake Co. Ind. (Deam no. 49,697) and Cook Co. Ill. (Field Museum herb. no. 485,663)
Coreopsis tripteris var. *deamii* Standley. Lake Co. Ind. (Standley, 1930)
Coreopsis tripteris var. *intercedens* Standley. Cook and DuPage Cos. Ill. and Porter Cos. Ind. (Standley, 1930)
Bidens discoidea (T. & G.) Britton. Porter Co. Ind. (Lyon, 1927)
Bidens aristosa var. *mutica* (Gray) Gatteringer. Porter Co. Ind. (Deam, 1928)
Senecio aureus var. *gracilis* (Pursh) Britton. Cook Co. Ill. (Greenman, 1903)
Senecio aureus var. *semicordatus* (M. & B.) Lake Co. Ind. (Greenman, 1903)
Senecio plattensis Nuttall. Porter Co. Ind. (Lyon, 1927)
Sonchus uliginosa Bieberstein. Cook Co. Ill. (Field Museum: Standley no. 57,450 and Benke nos. 5601 and 5608)

DELETIONS FROM THE FLORA OF THE CHICAGO REGION

Aspidium simulata. Referred to *Thelypteris palustris* Schott (Fassett, 1933)
Lycopodium clavatum. Northern in range, reports in error
Lycopodium obscurum. Referred to variety *dendroideum* Michaux
Panicum barbulatum.. Synonymous with *P. dichotomum* Linnaeus
Panicum scoparium. Referred to *P. scribnerianum* Nash (Deam, 1929)
Panicum huachucae silvicola and *P. tennesseense.* Synonyms of P. *lanuginosum* var. *fasciculatum* (Torrey) Fernald (*P. huachucae* Ashe)
Aristida gracilis. Referred to *A. intermedia* Scribner & Ball (Deam, 1929)
Bromus hordeaceus. Referred to *B. comutatus* Schrader (Fassett, 1933)
Agropyron biflorum. Referred to *A. caninum* forma *pubescens* (S. & S.) R. & P. (Deam, 1929)
Rynchospora corniculata. Referred to *R. macrostachya* Torrey (Fassett, 1933)
Rynchospora glomerata paniculata. Referred to the type.
Carex livida. An eastern form not found in the region
Carex stellulata cephalantha. Referred to the type only.
Juncus dichotomus and *J. setaceus.* Coastal plain forms only
Lilium canadense and *L. superbum.* Referred to *L. michiganense* Farwell
Smilax glauca. Referred to *S. hispida* Muhlenberg
Smilax rotundifolia quadrangulata. Referred to the type
Salix nigra falcata. Referred to the type, not distinguishable
Betula lenta. Referred to *B. lutea* Michaux (Deam, 1931)
Quercus stellata. Southern and eastern only
Quercus coccinea. Referred to *Q. ellipsoidalis* Hill
Quercus michauxii. Referred to *Q. muhlenbergii* Engelmann
Rumex elongatus. Included now in *R. crispus* Linnaeus
Salsola kali. Referred to the variety *tenuifolia* Meyer
Talinum teretifolium. Referred to *T. rugospermum* Holzinger
Mitella nuda. Referred to *M. diphylla* Linnaeus
Spiraea latifolia. Referred to *S. alba DuRoi*
Desmodium viridiflorum. Referred to *D. dillenii* Darlington
Oxalis filipes. Referred to *O. stricta* Linnaeus (Fassett, 1933)
Callitriche deflexa austini. Referred to *C. heterophylla* (Fassett, 1933)
Vitis cinerea. Referred to *V. labrusca* Linnaeus. (Fassett, 1933)
Circaea intermedia. An eastern form only, not found in area
Cornus asperifolia. A southern form only, not found in area
Nyssa sylvatica biflora. Referred to the type (Fassett, 1933)
Teucrium canadense littorale. Referred to *T. occidentale* Gray (Fassett 1933)
Physalis barbadensis. Referred to *P. pumila* Nuttall (Fassett, 1933)
Gerardia laevigata. Referred to *Aureolaria flava* (Linnaeus) Pennell (Fassett, 1933)
Gerardia pedicularia. Referred to the variety *ambigens* Fernald (Fassett, 1933)
Viburnum cassinoides. An eastern form not in this region
Viburnum dentatum. Referred to *V. affine* Bush and varieties
Vernonia altissima. Referred to *V. fasciculata* Michaux and *V. missurica* Rafinesque. (Fassett, 1933 in part correct)
Vernonia glauca. Referred to *V. missurica* Rafinesque (Fassett, 1933)
Lobelia puberula. A southern form not found in the region
Solidago arguta. Referred to *S. patula* Muhl (Fassett, 1933; Friesner, 1933)
Solidago bicolor. Referred to other species (Friesner, 1933)
Coreopsis major. A southern and eastern form not in region
Hieracium marianum. Referred to *H. gronovii* Linnaeus and *H. scabrum* Michaux (Fassett, 1933)

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A HERPETOLOGICAL CONSIDERATION OF FAUNAL AREAS IN SOUTHERN ARIZONA

BY

HOWARD K. GLOYD
Director

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A HERPETOLOGICAL CONSIDERATION OF FAUNAL AREAS IN SOUTHERN ARIZONA*

BY

HOWARD K. GLOYD
Director, The Chicago Academy of Sciences

Numerous publications have dealt with various features of the herpetology of Arizona but no attempt seems to have been made to correlate the distribution of amphibians and reptiles with the more general environmental conditions of the region. The only truly ecological study of these vertebrates in Arizona is that of Ruthven (1907) in which many valuable data are recorded but emphasis is placed on local habitat distribution in the vicinity of Tuscon. The many other publications on Arizona herpetology, although more or less replete with useful records of the occurrence of various species, contain little ecological information. The students of mammals and birds, on the other hand, have made more progress toward an analysis of the general environmental factors which influence animal distribution, and Arizona has had its share of attention.

My interest in this problem is chiefly an outgrowth of observations and collections made in the Southwest during the summers of 1930 and 1931. Subsequently I have examined a considerable number of additional specimens, assembled as much information as opportunities permitted on the distribution of Arizona reptiles, reviewed the literature on the vertebrates of southern Arizona and adjacent territory, and compiled some data on certain climatological and physiographical features of the region. On the basis of these considerations and my own observations in the field, I propose to define, provisionally, three so-called faunal areas of southern Arizona, and to place on record in the form

* Contribution from the Department of Zoology, University of Michigan.

of an annotated list of species certain herpetological notes which may be useful to those interested in the vertebrates of the region.

The collections which form the basis of this study were made in the region south of the Gila River for the Museum of Zoology, University of Michigan, and consist of approximately 1150 specimens representing 56 species and subspecies distributed among the various groups as follows: amphibians 8, lizards 27, snakes 19, and turtles 2. In addition to these I have examined the Arizona specimens in the Carnegie Museum, a considerable amount of material in the U. S National Museum, and numerous snakes and lizards received from friends and correspondents in Arizona. The annotated list is limited to species actually collected on the two expeditions or subsequently received as gifts to the Museum. Routes traveled and principal collecting stations will be described in a later section.

To President Alexander G. Ruthven and Mrs. Helen T. Gaige of the University of Michigan I am greatly indebted for making these expeditions possible. In 1930 Dr. Hobart M. Smith, then a student at the Kansas State College, Manhattan, was a member of the field party throughout the entire season and to his energy and skill as a collector are due many valuable specimens. Mr. W. H. Ditzler of Peru, Indiana, with his family joined the party in July, giving efficient and much-appreciated help in the Huachuca Mountains and in the Cañada del Oro. In 1931 Mr. Wilbur Doudna, a graduate student in forestry at the University of Michigan, accompanied us as far as Willcox, Arizona, where he collected in the Sulphur Springs Valley and the Chiricahua Mountains.

For many courtesies extended to us while we were in the field, I wish to express sincere appreciation to the following residents of Arizona: Captain H. M. Rose, Adjutant, Fort Huachuca; Mr. William Miller, U. S. Customs Inspector, Ajo; Deputy Sheriff Victor Gael and Mrs. Madeline R. Spain, Wellton; Mr. Leslie Wilcox, Hereford; Mr. and Mrs. Andrew Hood, Ramsey Cañon, Huachuca Mountains; Mr. and Mrs. A. H. Jelley and Mr. W. B. Covey, Willcox; and Mr. and Mrs. T. W. Bentley, Turkey Creek Ranger Station, Chiricahua Mountains. The officials of the Arizona Game and Fish Commission, particularly Messrs. R. L. Bayless, K. H. Pierson and S. L. Lewis, have cordially assisted us in every possible way.

Mr. M. Graham Netting of the Carnegie Museum, Pittsburgh, Pennsylvania, has kindly loaned for comparison and study the entire series of Arizona amphibians and reptiles under his care, and Dr. Leonhard Stejneger and Dr. Doris M. Cochran have cordially provided facilities for examination of specimens in the U. S. National Museum. Additional Arizona specimens have been received from Mr. Earl

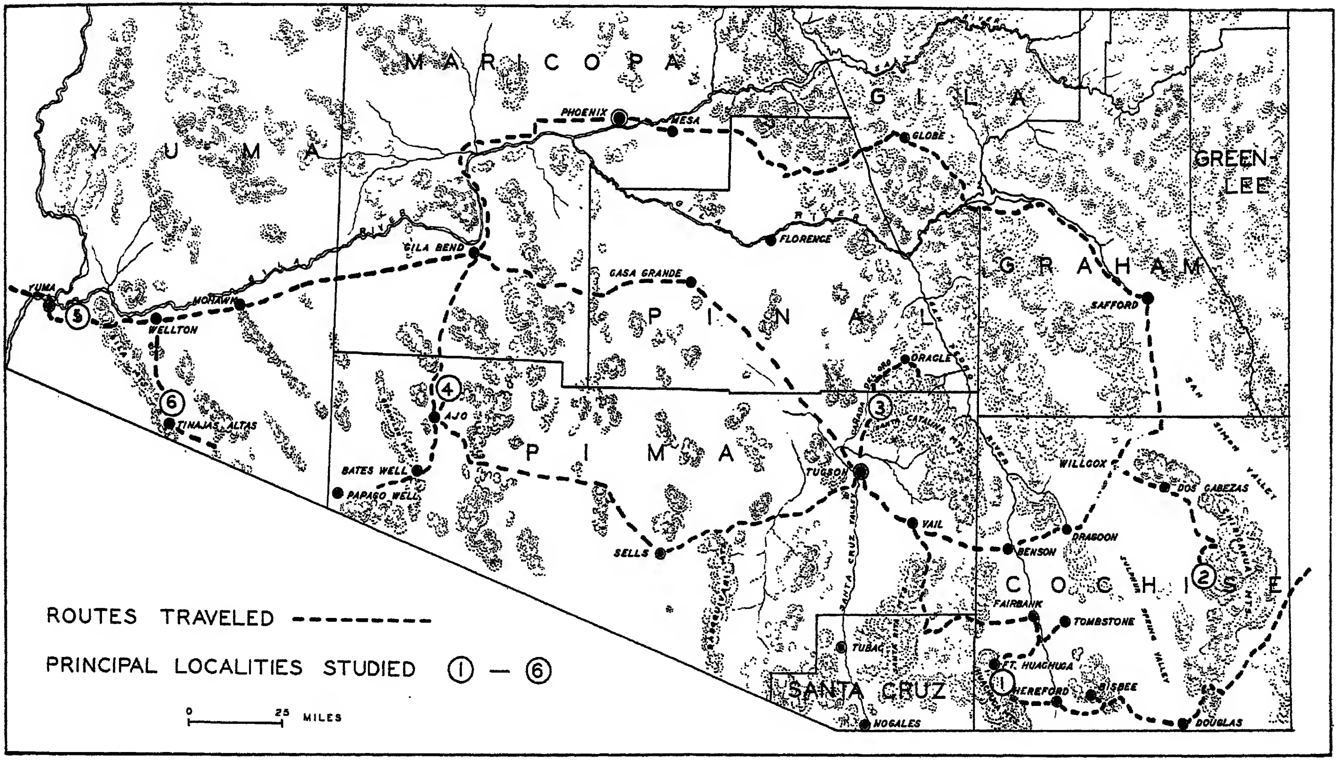

Fig. I. Sketch Map of Southern Arizona Showing Routes Traveled and Principal Collecting Stations.

Sanders, Mesa, Arizona, Mr. P. C. Bowman, Warren, Arizona, Dr. R. H. Painter, Kansas State College, Manhattan, Kansas, and Mr. Philip Blossom, University of Michigan.

Dr. Frank N. Blanchard and Mrs. Helen T. Gaige of the University of Michigan have given critical suggestions concerning matters of nomenclature and assistance in the identification of certain specimens. Finally, I wish to acknowledge my indebtedness and express my appreciation to my wife, Leonora K. Gloyd, who has shared in all the field work and has been inestimably helpful throughout the preparation of this report.

GENERAL FEATURES OF THE REGION

In the portion of Arizona which lies south of the Gila River, the lowlands may be characterized as a series of alluvial-plain valleys ranging in elevation from between 4000 and 5000 feet in the San Simon, Sulphur Springs, and San Pedro Valleys of the east to less than 200 feet above mean sea level in the Yuma Desert of the extreme southwest.* The lowland plains of Cochise, Santa Cruz, and extreme eastern Pima Counties support a grassland type of vegetation and are suitable for grazing, while to the westward of the Santa Catalina and Santa Rita Mountains the plains of the Papago Country contain only desert chaparral.

Separating these valleys at frequent intervals are numerous small mountain ranges, running mostly in a north and south direction (fig. 1), and of greatest extent and elevation in the eastern region where in east-central Cochise County an altitude of 9,795 feet is reached by Chiricahua Peak. These eastern mountains, especially the Chiricahua, Dragoon, Santa Catalina, Huachuca, Santa Rita, and Tumacacori groups of Cochise, Pima, and Santa Cruz Counties, receive enough rainfall to support a considerable growth of coniferous trees and a few species of hardwoods. All of the above mentioned ranges are included in the Coronado National Forest. The mountains to the westward, however, are the so-called "dead ranges", composed chiefly of igneous rocks, almost completely barren of vegetation and seldom with an elevation over 5000 feet, the average being between 3000 and 4000 feet.

In the region as a whole high temperature and low rainfall are the most outstanding features of the climate but there is much variation in these conditions between the extremes of the western and eastern portions. The averages of mean temperatures at certain stations for the

* Elevations from N. H. Darton's Topographical Map of the State of Arizona, 1923; Arizona Bureau of Mines in cooperation with the U. S. Geological Survey.

TABLE I. Averages of Mean Temperatures, in Degrees Fahrenheit, by Months, Seasons and Annually for Years between 1915 and 1930 at Certain Stations in Southern Arizona.

Station	Altitude	No. of Years of Record	Dec.	Jan.	Feb.	Winter	Mar.	Apr.	May	Spring	June	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Annual
Yuma	141	16	54.9	53.8	59.8	56.1	62.8	69.6	76.4	69.6	85.5	91.4	90.0	88.9	84.2	72.7	61.8	72.9	72.0
Gila Bend	737	8	51.1	52.6	56.1	54.3	62.4	67.5	75.5	68.4	86.7	92.7	90.5	89.9	84.5	73.3	60.3	72.7	71.5
Ajo	1,805	16	53.5	52.0	56.4	53.9	60.8	67.8	75.6	68.0	85.6	89.0	87.7	87.4	83.4	72.8	61.4	72.5	70.5
Tucson	2,400	16	50.3	49.6	53.6	51.1	56.9	62.7	71.4	63.6	80.8	85.1	82.8	82.9	78.5	68.3	57.3	68.0	61.5
Ft. Huachuca	5,000	3	50.9	41.9	44.7	46.8	51.8	58.0	61.4	58.0	75.6	75.3	76.4	75.7	72.0	65.9	54.6	64.1	61.5
Douglas	3,930	15	45.2	45.0	49.8	46.6	50.3	60.2	68.1	59.5	77.7	79.7	77.6	78.1	73.7	63.7	52.3	63.2	62.3

TABLE II. Average Rainfall in Inches by Months, Seasons and Annually for the Period between 1915 and 1930 at Certain Stations in Southern Arizona.

Station	Altitude	No. of Years of Record	Dec.	Jan.	Feb.	Winter	Mar.	Apr.	May	Spring	June	July	Aug.	Summer	Sept.	Oct.	Nov.	Fall	Annual
Yuma ..	141	16	.66	.53	.14	.44	.25	.09	.02	.12	.01	.18	.49	.23	.72	.22	.11	.35	3.42
Gila Bend	737	10	.55	.97	.41	.61	.62	.17	.20	.33	.06	.77	1.14	.65	.70	.16	.33	.39	6.10
Ajo	1,805	16	.98	.92	.58	.83	.72	.42	16	.43	.06	1.68	1.74	1.16	.88	.30	.59	.59	9.48
Tucson	2,400	16	.80	.89	.72	.80	.85	.50	.22	.52	.32	2.23	1.82	1.40	1.55	.44	.83	.94	11.30
Ft. Huachuca	5,000	9	34	1.36	.51	.71	.66	.32	.30	.46	.56	5.12	3.38	3.02	1.21	.28	.64	.72	14.76
Douglas	3,930	16	.62	.72	.43	.59	.45	.30	23	.32	.44	3.85	2.39	2.23	1.56	.73	.67	.97	12.27

years between 1915 and 1930 are given in Table I, and the average rainfall for the same stations during the same period in Table II. The summer heat is intense and in the desert lowlands of the lower Gila Valley, at Yuma and Gila Bend, temperatures higher than 100°F. occur frequently and such extremes as 119° and 121° sometimes are recorded (see Table III). In this area killing frosts rarely if ever occur.

TABLE III. Highest and Lowest Temperatures, in degrees Fahrenheit, Recorded between 1915 and 1930 at Certain Stations in Southern Arizona.

Station	Yuma	Gila Bend	Ajo	Tucson	Ft. Huachuca	Douglas
Highest	119	121	115	112	105	108
Lowest	28	21	22	15	11	12

In the eastern part of the region, as the altitude increases, summer temperatures are less severe and there is a distinct though mild winter. the eastern mountains but residents of Ramsey Cañon in the Huachuca Unfortunately no weather data are available for the higher elevations of Mountains told us that in some years there is considerable snowfall during the months of January and February. The rainfall varies considerably at different points across the southern part of the state (Table II.) In general the areas of lowest elevation receive the smallest amount of rain. Precipitation is least in the lower Gila Valley where it is rarely more than three inches annually. It increases gradually toward the east, reaching an average of 11.3 inches at Tucson, 12.27 at Douglas, 14.76 at Fort Huachuca, and probably a somewhat higher figure in the mountains. In most of this area the greater amount falls during the months of July and August while the spring months are the driest. In the vicinity of Yuma, however, there is more rain in the fall and winter than during the remainder of the year.

DESCRIPTIONS OF LOCALITIES STUDIED

The routes traveled in southern Arizona are indicated on the accompanying map (fig. 1). Although frequent brief stops were made for collecting at many points on the various highways, certain regions were especially selected for more intensive work. These localities, in which from four days to nearly three weeks were spent, are indicated by numbered circles and will be described in order.

Fig. 2. Huachuca Mountains from the east, Miller Peak at left of center, Carr Peak to the right

1. HUACHUCA MOUNTAINS, southwestern Cochise County. The Huachuca Mountains rise from a plain with an elevation of slightly more than 4000 feet to a height of 9445 feet on Miller Peak and 9214 feet on Carr Peak (fig. 2). The main axis of the range runs from north-northwest to south-southeast and the southern extremity reaches the Mexican Border near International Monument No. 102 (Mearns, 1907, p. 101). The higher timberline is not reached at any point in the range (fig. 3) but the lower timberline extends down to and out upon the surrounding plain opposite the mouths of some of the cañons. The eastern slopes support considerable vegetation and are deeply incised by a series of more or less parallel cañons, the less precipitous sides of which are in many places heavily wooded with oaks, pines, cedars, and spruces. Agaves of two or three species and occasional sotols and yuccas (fig. 4) are encountered at almost all elevations and, in the lower portions of the cañons, acacias and mesquite form numerous thickets of chaparral. Numerous trails lead to "prospects" or mines most of which have long since been abandoned. In the upper end of Ramsey Cañon at an elevation of slightly less than 7000 feet are the ruins of the old Hamburg Mine of interest to herpetologists as the probable type locality of *Crotalus willardi* Meek, and

FIG 3 Ramsey Cañon, Huachuca Mountains Note rock slide on steep slope at left, a habitat of *Crotalus lepidus klauberi* *Eumeces callicephalus* was found on side of cliff at lower right

F[illegible] Habitat of *S*[illegible] [illegible] *Gerrhonotus kingii* and *Lampropeltis pyromelana* in Ramsey Cañon, Huachuca Mountains

one of the two places in which this species has been collected north of the Mexican Border.

The lowland vegetation of the San Pedro and Sulphur Springs Valleys consists of desert grassland with scattered shrubs such as mesquite, creosote bush and cat's claw with occasional agaves and yuccas.

Although the Huachuca Mountains have proved to be fertile collecting grounds for many years, conditions affecting the natural fauna of the region are changing. The area is becoming more thickly settled, the adjoining plains are now fenced pastures, several of the cañons contain numerous dwellings with milch cows enclosed on the tiny grassy meadows above, and in Ramsey and Miller Cañons are summer resorts and picnic grounds. In spite of this, much remains of interest to the herpetologist. That the field is not exhausted is indicated by the recent discovery in Ash and Ramsey Cañons of a lizard new to the fauna of the United States (Taylor, 1929).

The time spent by our party in the Huachuca Mountains was from July 18 to August 1, 1930, and from July 4 to 13 and September 2 to 5, 1931. From camps in Carr and Ramsey Cañons we collected at numerous localities and elevations in Ash, Carr, Ramsey, Miller, and Montezuma Cañons as well as on the surrounding plain

Fig. 5. Morse Cañon, Chiricahua Mountains. Habitat of *Crotalus triseriatus pricei*. The photograph used as figure 21 was made on the ridge shown above at lower right.

2 CHIRICAHUA MOUNTAINS, eastern Cochise County. The Chiricahua range lies mostly north and south and reaches a greater elevation than the Huachuca Mountains Chiricahua Peak, altitude 9795 feet, is with one exception the highest mountain in southern Arizona The general topography and the main features of the vegetation are similar to those of the Huachucas. In the region of Turkey Creek and Morse Cañon, the area briefly visited by our party, there was a conspicuous absence of the agaves and sotols which characterize the more southern mountain groups (fig. 5). The Chiricahua region is more sparsely settled and seems to be less completely known scientifically than the Huachucas.

Mrs Gloyd and I camped on Turkey Creek on the western slope from August 20 to 23, 1931. During this season Mr Doudna spent some time at the Riggs Home Ranch in the edge of the western foothills, making a few trips to higher elevations.

Southeastern Arizona has received considerable attention from early naturalists and collectors The Pacific Railroad Reports (Baird and Hallowell, 1859), Baird's report on the reptiles of the Mexican Boundary Survey (1859), Yarrow's section on the reptiles of the Wheeler Survey West of the 100th meridian (1875), and Coues' Synopsis of the Reptiles and Batrachians of Arizona (1875) contain many indefinite records such as "southeastern Arizona" which in the case of such mountain species as *Sceloporus jarrovii, Sceloporus scalaris, Lampropeltis pyromelana,* and *Crotalus lepidus* doubtless apply to the mountain ranges such as the Huachucas and Chiricahuas. Apparently the first general paper dealing primarily with the Huachuca Mountains and vicinity was that of Van Denburgh (1896) on a collection made by W W. Price in 1893 and 1894. Then followed Stejneger's paper on the reptiles of the Huachuca Mountains (1902) describing collections made by himself and others. Notes on the flora and fauna of the Huachucas, including a list of reptiles, were included in Mearns' work on the mammals of the Mexican Boundary (1907, p. 101-105). A paper by Stone (1911) included a series of specimens from this mountain range. Mr. J. R. Slevin of the California Academy of Sciences visited this region when collecting in Arizona in 1912 and a report on the specimens secured, and material obtained from other sources, appeared the following year (Van Denburgh and Slevin, 1913). The most complete treatment of the herpetology of the region appears in Van Denburgh's *Reptiles of Western North America* (1922) and Slevin's *Amphibians of Western North America* (1928).

3. CAÑADA DEL ORO; western edge of the Santa Catalina Mountains, between Tucson and Oracle, Pima and Pinal Counties.

Fig 6 Sahuaro-ocotillo association in desert on east side of Cañada del Oro, twenty miles north of Tucson Habitat of *Heloderma suspectum* *Cnemidophorus sexlineatus perplexus* *Callisaurus draconoides ventralis*, and *Crotalus tigris* Foothills of the Santa Catalina Mountains in background

The Cañada del Oro (literally translated—"Gully of Gold") is a narrow valley probably named by one of the early Spanish explorers who traveled across this region during the 16th century. Through it during the rainy season flows a shallow stream which joins the Santa Cruz River about ten miles northwest of Tucson. The valley floor is dissected by numerous sandy arroyos on the slopes from the Tortillita Mountains on the northwest and the Santa Catalina Mountains on the southeast.

When compared with the desert region to the westward, the Cañada del Oro may be characterized as an area of increased rainfall and an abundance of desert vegetation (fig. 6). The most conspicuous cacti are the giant cactus or sahuaro (*Carnegiea gigantea*), the barrel cactus or bisnaga (*Echinocactus wislizenii*), several species of jointed cactus, prickly pear, and cholla (*Opuntia* sp.), the latter sometimes reaching a height of six feet, and the ball cacti (*Mammillaria*). Among the trees and woody shrubs the most abundant forms are the palo verde (*Parkinsonia*), mesquite (*Prosopis*), ocotillo (*Fouquieria splendens*), the cat's claws or acacias (*Acacia greggii* and others), the crucifixion thorn (*Holocantha emoryi*), and the desert willow (*Chilopsis linearis*). Yuccas, sotols and agaves occur in the cañon mouths and foothills of the Santa Catalina Mountains.

From August 1 to 13, 1930, our camp was located on the east side of the valley, 19 miles north of Tucson, at an elevation of about 3000 feet, and most of the specimens recorded from the Cañada del Oro were collected within a two-mile radius of this location. Reptile life, both with respect to number of species and number of individuals, was strikingly abundant, lizards especially being present in greater numbers than in any other region visited.

Besides the general works on western herpetology already mentioned, other faunal papers dealing with the Tucson region and the Cañada del Oro have been published by Ruthven (1907), Ortenburger and Ortenburger (1926), MacCoy (1932), and King (1932). Mearns (1907, p. 108-111) has given a brief description of the country near Tucson and Old Fort Lowell with comments on the richness of the fauna and a list of the reptiles collected during the work of the International Boundary Commission of 1892-94.

4. WELL NO. 1, an underground pumping station of the Calumet and Arizona Mining Company, 7 miles northeast of Ajo, western Pima County.

As one travels westward from Tucson across the region known as the Papago Country*, there is a gradual drop in the elevation of the desert valleys from slightly above 2400 feet near the Santa Cruz River south of Tucson to about 1500 feet in the "Valley of the Ajo" just east of the Growler Mountains (see map fig. 1). The small, low, isolated mountain groups, composed of a variety of volcanic rocks, are almost destitute of vegetation and are known as the "dead ranges." The flora of the desert is similar in its general nature to that of the Tucson region but scanty in comparison, the individual plants being more or less widely separated by barren rocky areas. The creosote bush (*Covillea tridentata*) characteristic of the western lowlands becomes relatively abundant and may be considered the dominant shrub.

The region in the immediate vicinity of Ajo and Well No. 1 may be described briefly as a creosote bush desert with occasional mesquite shrubs rarely more than five or six feet in height, a few palo verdes and acacias, with the cacti represented principally by scatterd chollas and sahuaros (figs. 7 and 8). The soil is mostly hard and rocky, areas near mountains being strewn with lava talus; accumulations of wind-blown sand are infrequent.

At the time of our visit no rain had fallen for many weeks, the sky was practically cloudless, and the temperature reached 108°F. daily. From August 14 to 17 inclusive, 1930, we collected in the

* For a detailed discussion of the geology, physiography and climate of this region see Bryan (1925)

Fig. 7. Desert plain near Ajo. Mesquite and creosote bush are the dominant forms of vegetation. Habitat of *Cnemidophorus tessellatus*, *Dipso-saurus dorsalis* and *Crotalus cerastes*.

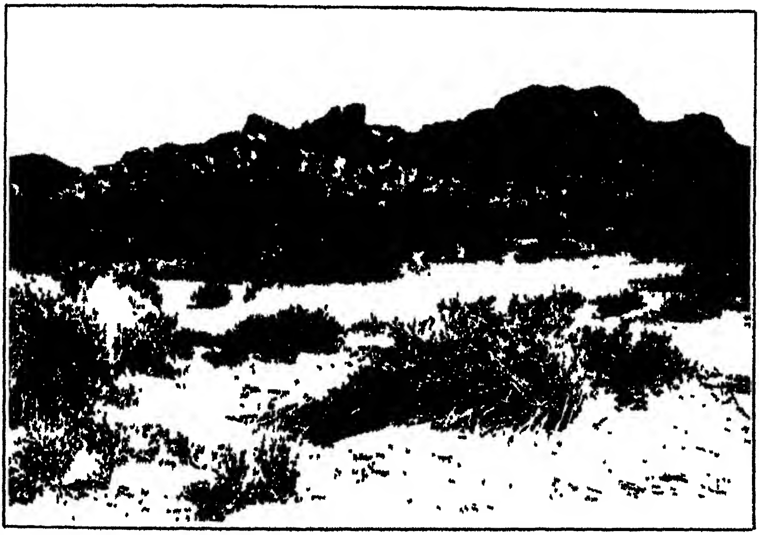

Fig. 8. The Papago Country near Bates Well, a creosote bush desert with scattered growths of mesquite and sahuaro. The Growler Mountains, one of the "dead ranges", in background.

vicinity of Well No. 1 and Ajo and made a one-day trip south and west through Growler Pass to Bates Well and into Growler Valley (see map, fig. 1) It was our intention to follow this route westward, joining the old Spanish trail, "El Camino del Diablo", near Papago Well and continuing to Yuma by way of Tule Tank and Tinajas Altas Upon learning of the almost impassible condition of the road, however, this plan was abandoned.

Practically no previous herpetological work has been done in this area Dr. Mearns and his assistants gave some attention to the amphibians and reptiles during the marking of the International Boundary in 1894 (Mearns, 1907) listing a few species collected at that time

5. GILA VALLEY, six miles east of Yuma, Yuma County.

With its low elevation of under 150 feet, its extreme dryness and high temperatures (see Tables I - III), and its dearth of the larger types of vegetation, this region represents American desert conditions exceeded in severity perhaps only in the Salton Sea area and Death Valley, California. The south side of the Gila Valley for some miles east of Yuma is a series of low ridges of soft sand more or less parallel with the river The vegetation consists of a sparse growth of creosote bush and bur-sage (*Franseria*) with infrequent mesquite trees (fig. 9).

The location of our Gila Valley camp from August 18 to 22, 1930, was between five and six miles east of Yuma and about a mile south of the river. The high temperatures restricted our collecting activities to early morning, late afternoon and after nightfall.

Because of its accessibility and its special points of interest this area has attracted the attention of collectors and its fauna is well represented in western museums. The general herpetological works of Van Denburgh (1922) and Slevin (1928) have summarized the records of reptiles and amphibians of this region up to their respective dates of publication.

6 TINAJAS ALTAS, twenty-eight miles south of Wellton, southern Yuma County.

Tinajas Altas, or "high tanks", is the name of a watering place on the eastern side of a small range of granite mountains bearing the same name but in reality a southern prolongation of the Gila Range A series of eight rock tanks, distributed for 500 feet along a stream course so steep that it may be considered an almost continuous series of falls, is filled during the rainy season by surface drainage from a small upland valley with relatively gentle slopes.* Water of a sort

* See Bryan, 1925, p 132 134, pl 18, for a complete description of the geological and physiographical features of these tanks and their environs

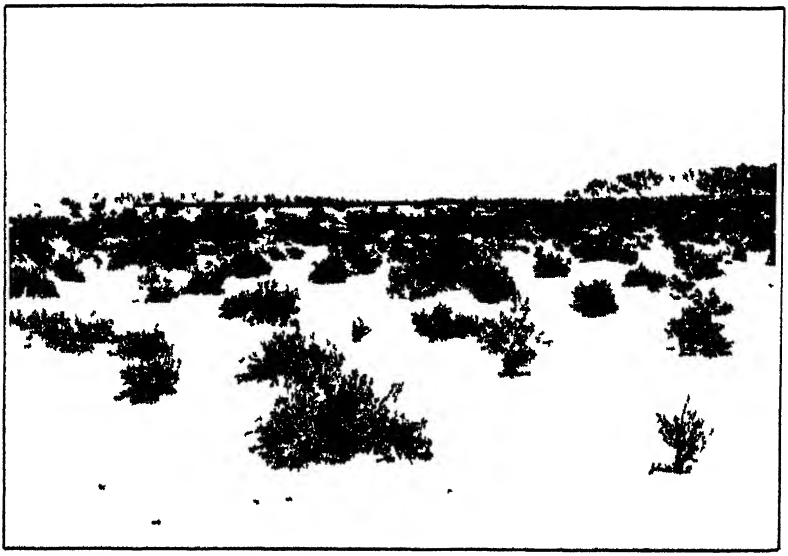

Fig. 9. Desert of the Gila Valley east of Yuma. Soft sand habitat of *Callisaurus draconoides ventralis*, *Sonora occipitalis* and *Crotalus cerastes*.

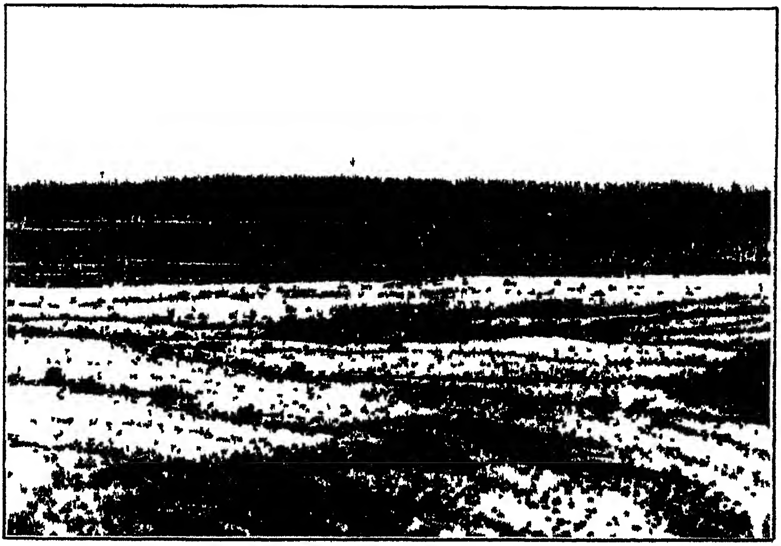

Fig. 10. Lechuguilla desert looking southeast from Tinajas Altas, the Cabeza Prieta Mountains in the distance. The road is "El Camino del Diablo."

is available here during most of the year. The lowest tank is accessible to horses and has been in use for many years by travelers of the famous "Camino del Diablo", one of the main routes from Mexico to California during the Gold Rush of the fifties.

Climatic conditions in this locality are similar to those of the Yuma region but the soil and vegetation differ. The mountain slopes are barren and strewn with talus and the soil of the adjoining valley, the Lechuguilla Desert, is hard and rocky with little or no loose sand except in the beds of arroyos (fig. 10). The vegetation is sparse, the dominant shrub creosote bush. Occasional ocotillo, palo verde, palo fierro or ironwood (*Olneya*), acacias and mesquite trees occur, and among the cacti the jointed forms or chollas are most common although scattered bisnagas and sahuaros are present.

With the exception of the few specimens collected by Mearns during the marking of the Boundary in 1894 (Mearns, 1907, p. 122-124), no previous herpetological collecting seems to have been done in this part of the Papago Country. Records based on some of the Mearns material in the National Museum have been published by Van Denburgh and others.

The period spent at Tinajas Altas by Mrs. Gloyd and myself was from August 25 to 30, 1931.

DISCUSSION OF FAUNAL AREAS

Practically all of Arizona south of the Gila and Salt Rivers lies within the Austral Region and most of it within the Lower Austral or Lower Sonoran Life Zone. The Upper Sonoran is represented only in the foothills, cañons, and slopes of the larger mountain groups in the southeastern portion. Only a few of the mountain ranges considered in this paper (viz., the Santa Catalina, Santa Rita, Huachuca, and Chiricahua) have sufficient elevation to exhibit characteristics of the Transition Zone. Therefore, a discussion of the details of animal distribution in this area must deal very largely, if not exclusively, with the Lower Sonoran Zone.

The term "faunal area", as indicated by Grinnell (1914, p. 64; 1915, p. 9-12), is applied to a natural subdivision of a life zone which maintains enough uniformity in temperature, rainfall, and other environmental factors to support a characteristic and distinctive group of animal and plant species. That this is a useful concept to students of animal distribution, I think no one will dispute, although, as clearly stated by Grinnell, insufficient data are available to permit statistical analysis of the various aspects of this problem. In this brief

report it is not possible to review even the most important contributions to this phase of zoogeography. Certain papers dealing wholly or in part with southern Arizona, however, can profitably be considered since they form the basis for the application of my own observations.

In his *Mammals of the Mexican Boundary of the United States*, (1907), which contains a wealth of data useful to the student of the southwestern vertebrate fauna, and which appears to have been somewhat overlooked by herpetologists, Dr. Mearns described and mapped (p. 73-74, pl. 2) a number of "differentiation tracts" based upon his study of variation in mammals collected along the International Boundary from the Gulf of Mexico to the Pacific Ocean. While these tracts are not discussed at length, it seems that this author had in mind a concept similar to that of more recent workers who have used the term "faunal area". Two of Mearns' differentiation tracts include the southern Arizona region. His "elevated central tract" extends from the eastern border of the state to the "Sonoyta River Valley, west of the Cabota and Nariz Mountains", or, in terms of landmarks north of the border, the Ajo and Pozo Redondo Mountains. His "western desert tract" includes the territory from the Sonoita Valley "to the east base of the Coast Range", or roughly the Colorado Desert of Arizona and California. Swarth (1929), as the result of studies on the distribution of birds and mammals, described two faunal areas in southern Arizona: an "eastern plains area" in the southeastern corner of the state, bounded on the west by the Santa Rita Mountains, and a "western desert area" extending from the Santa Rita Range to the Colorado River.

It will be seen that both these writers recognized certain faunal differences indicated by characteristically different species in the eastern and western parts of this region. The central section, with its unusually rich fauna and flora, seems not to have received its full measure of consideration, the one author combining it with the higher plains of the east, the other including it with the lower desert of the west.*

From a consideration of the distribution of reptiles as indicated by my own collections and observations, additional museum material examined, and a study of herpetological literature, I consider it desirable

* As this manuscript goes to press there has come to hand a paper by A. J. van Rossem (Notes on birds in relation to the faunal areas of south central Arizona. Trans. San Diego Soc. Nat. Hist., vol. 8, pp. 121-148, pls. 17-18, 3 maps) which discusses faunal areas in southern Arizona. Mr. van Rossem concludes "that southeastern Arizona [west to the Baboquivari Mountains] is, on the basis of its Lower Sonoran, Upper Sonoran, and Boreal Zone birds, the northwestern portion of a large and well characterized area of differentiation which has as its geographical hub the mountain mass of the northern Sierra Madre which lies north of the east-west course of the Yaqui River." Although this advocates a more western boundary, the Baboquivari Mountains, for the Eastern Plains Area, it is not inconsistent with my conclusions.

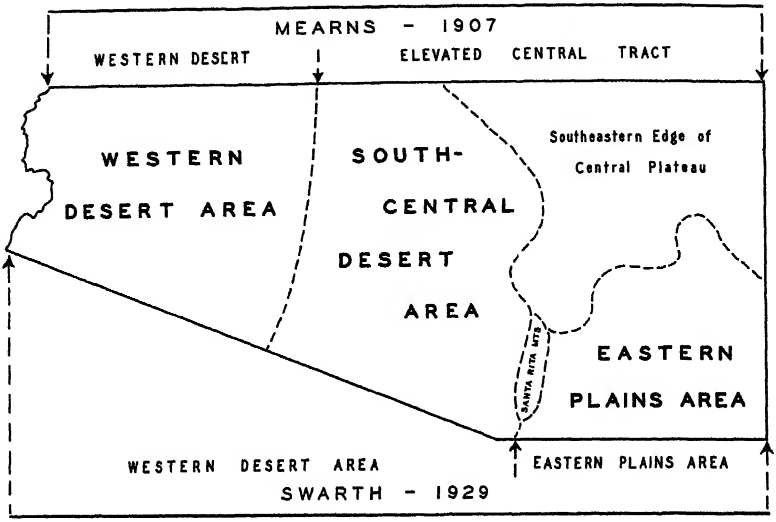

Fig. 11. Diagram showing the relationship of the Faunal Areas proposed in this paper to those of Mearns (1907) and Swarth (1929).

to recognize three faunal areas in the lowlands (Lower Sonoran) of southern Arizona: (1) an Eastern Plains Area as delimited by Swarth (*loc. cit.*), (2) a Western Desert Area with approximately the same eastern boundary as that suggested by Mearns, and (3) a South Central Desert Area occupying the intervening region, approximately from the vicinity of Ajo and Gunsight on the west to the Santa Rita Mountains in the east, extending northward to the lower edge of the highlands north of Phoenix and southward indefinitely into Sonora along the western border of the Mexican Plateau. Reference to figures 1 and 11 will make clear the relationships of these three classifications. The higher elevations of the eastern mountains (Upper Sonoran and Transition Zones) are, of course, excluded from these three categories since their reptile fauna differs conspicuously from that of the surrounding deserts and plains, and from that of the relatively barren western mountains.

That each of these areas differs from the others in elevation and in such climatic features as temperature and rainfall is indicated in tables I and III. Of the three, the Eastern Plains Area, which roughly coincides with the boundaries of Cochise County, is the most distinct.

The vegetation is of the plains type and the fauna also appears to be definitely related to that of the Great Plains. As Swarth has pointed out (*loc. cit.*, p. 270), the Santa Rita Mountains form a tangible natural boundary on the west.

The dividing line between the Western Desert Area and the South Central Desert Area is not so obvious. Swarth (*loc. cit.*, p. 277) with reference to the Mearns classification says, "I can not appreciate any reason for the dividing line he draws across the desert midway between Tucson and Yuma, with the 'Western Desert Tract' to the westward, the 'Elevated Central Tract' to the eastward. Neither is there any general division of forms in mammals, birds or plants along that line, nor is there any marked change in altitude or climate." His figure G, p. 277, however, indicates that *Lepus alleni alleni*, the Antelope Jack Rabbit, a member of a group principally Mexican in distribution, is confined to a region in south central Arizona which corresponds rather nicely to this South Central Desert Area. He further states (p. 365) that the dividing line between the forms *eremicus* and *deserticola*, subspecies of *Lepus californicus* which occurs uninterruptedly across southern Arizona, lies somewhere near the western limit of the range of *Lepus alleni*. This also corresponds with the approximate western boundary of the South Central Desert Area.

Arizona jack rabbits have been studied more recently by Vorhies and Taylor (1933). In a discussion of the range of *Lepus alleni*, these authors state (p. 480) that they "are unable to determine the factors limiting the distribution of the Antelope Jack Rabbit . . . There are no appreciable physical or climatic barriers *except to the westward* [italics mine]. In the vicinity of Gunsight, Pima County [the approximate western limit of the South Central Desert Area], the soil and vegetation change somewhat, the soil becoming softer and more sandy."

I have not gone deeply into a study of the distribution of Arizona birds and mammals, but a careful consideration of the distribution of reptiles in this region, in my opinion, amply justifies the recognition of some set of environmental factors, as yet not understood, which limit the spread of certain species at approximately this point.

The distribution of southern Arizona reptiles, determined as accurately as my present facilities permit, is summarized in table IV. The list given here does not include all species that have been recorded from the region. Most of those that could be added are either so rare or little known that they would not materially help the problem in hand. For this reason it is thought best to limit the number to the species personally studied. Since the amphibians of this region are for the most part wide-ranging species the distribution of which is

TABLE IV
Distribution of Southern Arizona Reptiles by Faunal Areas

SPECIES	Western Desert Area	South Central Desert Area	Eastern Mountains	Eastern Plains Area
Coleonyx variegatus	*********	********		* *
Dipsosaurus dorsalis dorsalis	********			
Crotaphytus collaris baileyi	*********	********		*********
Crotaphytus wislizenii	*********	* * *		
Sauromalus obesus	********	* * *		
Callisaurus draconoides ventralis	*********	*********		* * * *
Holbrookia elegans		*********		
Holbrookia maculata approximans		* * *		*********
Holbrookia pulchra			*********	
Holbrookia texana		* * *		*********
Uta graciosa	********			
Uta ornata symmetrica	*********	*********	* **	*********
Uta stansburiana stejnegeri	*********	*********		*********
Sceloporus clarkii clarkii			*	*********
Sceloporus jarrovii jarrovii			*********	
Sceloporus magister magister	*********	* *******		
Sceloporus scalaris			*********	
Sceloporus undulatus consobrinus			*	*********
Phrynosoma cornutum				*********
Phrynosoma douglassii hernandesi			********	*
Phrynosoma modestum				*********
Phrynosoma platyrhinos	*********			
Phrynosoma solare	* * * *	********		* * *
Gerrhonotus kingii			*********	
Heloderma suspectum	* * * *	*********		* * *
Cnemidophorus sexlineatus perplexus		*********		*********
Cnemidophorus tessellatus tessellatus	*********	*********		* * * *

TABLE IV
Distribution of Southern Arizona Reptiles by Faunal Areas

SPECIES	Western Desert Area	South Central Desert Area	Eastern Mountains	Eastern Plains Area
Eumeces callicephalus			*********	
Eumeces obsoletus			*	*********
Heterodon nasicus				*********
Masticophis semilineatus		*********	* *	*********
Masticophis flagellum frenatus	*********	*********		*********
Masticophis piceus		*********		
Salvadora hexalepis	*********	*********		*********
Pituophis sayi affinis	*********	*********	* *	*********
Lampropeltis getulus splendida		*********		*********
Lampropeltis getulus yumensis	*********	*********		*********
Lampropeltis pyromelana			*********	
Sonora occipitalis	*********			
Thamnophis eques		*********		*********
Thamnophis megalops	*	*********		**
Thamnophis marcianus	*********	*********		*********
Trimorphodon lyrophanes	*	*********	*	* * *
Micruroides euryxanthus	*	*********		**
Crotalus cinereous	*********	*********		*********
Crotalus cerastes	*********	* * *		
Crotalus lepidus klauberi			*********	
Crotalus molossus molossus		*	*********	**
Crotalus scutulatus	*********	*********		*********
Crotalus tigris		*********		
Crotalus triseriatus pricei			*********	
Gopherus agassizii	*********	*********		
Terrapene ornata		*		*********

chiefly determined by the presence of water, their occurrence is not considered of significance in this connection. An exception to this statement is *Bufo alvarius* which rarely occurs east of the desert areas.

Excluding the typical mountain species, and also the plastic lowland forms known to range entirely across the state, the remaining may be divided into five groups:

I. SPECIES ENTIRELY OR CHIEFLY RESTRICTED TO THE EASTERN PLAINS AREA AND THE FOOTHILLS OF THE EASTERN MOUNTAINS:

Sceloporus clarki
Sceloporus undulatus consobrinus
Phrynosoma cornutum
Phrynosoma modestum
Eumeces obsoletus
Heterodon nasicus
Terrapene ornata

II. SPECIES CHARACTERISTIC OF THE EASTERN PLAINS AREA BUT OCCURRING ALSO IN THE SOUTH CENTRAL DESERT AREA:

Holbrookia maculata approximans
Holbrookia texana
Cnemidophorus sexlineatus perplexus
Lampropeltis getulus splendida
Thamnophis eques

III. SPECIES ENTIRELY OR CHIEFLY RESTRICTED TO THE WESTERN DESERT AREA:

Dipsosaurus dorsalis dorsalis
Uta graciosa
Phrynosoma platyrhinos
Sonora occipitalis

IV. CHARACTERISTICALLY DESERT SPECIES OCCUPYING THE WESTERN AND SOUTH CENTRAL DESERT AREAS, SOME OCCASIONALLY INTRUDING INTO THE EASTERN PLAINS AREA:

Coleonyx variegatus
Crotaphytus wislizenii
Sauromalus obesus
Callisaurus draconoides ventralis
Sceloporus magister
Phrynosoma solare
Heloderma suspectum
Lampropeltis getulus yumensis
Trimorphodon lyrophanes
Micruroides euryxanthus
Crotalus cerastes
Gopherus agassizii

V. SPECIES APPARENTLY RESTRICTED TO THE SOUTH CENTRAL DESERT AREA, OR IMMEDIATELY ADJACENT TERRITORY:

Holbrookia elegans
Cnemidophorus sexlineatus perplexus (giant form, see p. 101, 115).
Masticophis piceus
Thamnophis megalops
Crotalus tigris

It will be noted that the species of Group I are practically all characteristic of the Great Plains Province with major portions of their ranges east of Arizona. The Arizona populations of these species, therefore, represent a peripheral plains fauna to which the deserts

present a definite barrier to westward spreading. Group II is composed of more plastic forms, apparently also immigrants from the Plains, or at least with the centers of their ranges to the eastward, which are apparently able to endure greater aridity than those of Group I, but which seem unadaptable to the extreme desert conditions of the Colorado Valley. In marked contrast to these are the species comprising Group III, all highly adapted to desert conditions and restricted to the more soft and sandy soil of the Western Desert Area. The range centers of these forms all lie to the westward, the Arizona populations thus being peripheral to a fauna spreading into this area from the west. The species of Group IV, ranging across both Western and South Central Desert Areas, are less restricted in distribution than those of the preceding. Most of them are also apparently of western origin but some (*Phrynosoma solare, Heloderma suspectum, Trimorphodon lyrophanes*, and *Micruroides euryxanthus*) appear to be most characteristic of the South Central Area, spreading out of it both to the eastward and westward, and probably are derived from southern stock. Group V includes the forms indigenous to the South Central Desert Area. Three of these, *Holbrookia elegans, Thamnophis megalops* and *Crotalus tigris,* seem clearly to be of southern origin since their ranges are far more extensive in Mexico than in the United States. *Masticophis piceus* is known only from this area in south central Arizona and from Lower California (Ortenburger, 1928, p. 130). Its apparent absence from the deserts of the Colorado Valley is a range discontinuity similar to that of *Crotalus viridis oreganus* (Klauber, 1930, p. 130, 135) and *Trimorphodon lyrophanes* (Klauber, 1928, p. 191, pl. 22). Whether or not the two populations of *Masticophis piceus* and of *Crotalus v. oreganus* thus separated by the Colorado Desert are in each case conspecific, this strip of austere territory now seems to prevent their intermingling.

That *Cnemidophorus sexlineatus perplexus* reaches an extremely large relative size in the South Central Desert Area, as noted by Ruthven (1907, p. 557) and Van Denburgh and Slevin (1913, p. 408) in the Tucson region, has a special interest in connection with this problem. In a more recent study, Burt (1931, p. 129) concluded that these giant lizards represent an end form in the evolution of color pattern. Such a phenomenon may readily be accompanied by a tendency toward giantism and is all the more probable at the periphery of the range, as is the case here (Burt, *loc. cit.*, fig. 23). At the very least, it is suggested that the south central part of Arizona offers a very favorable environment for this species.

The South Central Desert Area, then, appears to be a meeting

place for a varied assemblage of faunal elements. the westernmost branches of numerous eastern species, the eastern outposts of a group of species probably of western origin, an intrusion of southern forms from the edge of the Mexican Plateau, and along with all these, a considerable number of more plastic Lower Sonoran species which range continuously across the entire area. From these considerations, the extreme richness of the herpetological fauna of south central Arizona can be appreciated.

In concluding this discussion, I wish to comment briefly upon a paper by the late J. Eugene Law (1929) published as a critique of Mr Swarth's study (1929) to which I have made frequent reference. Mr. Law apparently took a less optimistic view of the problem of subzonal environmental factors and seriously questioned the desirability of defining faunal areas in general terms, citing numerous instances in which he considered Swarth's indicator species invalid because of their occurrence to the one side or the other of the approximate limits of the areas defined

It is certainly not my intention, and neither, I think, was it Mr. Swarth's, to convey an idea of inflexible limiting lines in describing these areas. Mr. Law pointed out that each species responds in its own way to the several associational factors present, and with this I readily agree. When we find, however, a group of species responding to certain environmental factors in a manner sufficiently similar to restrict them to a limited area, we may assume the existence of a barrier, tangible or otherwise. Only such barriers as affect an appreciable number of species can, of course, profitably be used in delimiting faunal areas. Naturally, one could increase the number of such areas to the total number of species in a given region if all the idiosyncracies of habitat requirements and complete range of each could be known. There would be no gain in this. The faunal area concept must necessarily be at least as arbitrary as that of the Life Zones. Both serve a useful purpose in giving a certain unity to observed facts until, through increase in knowledge of animal responses to topographical, meteorological, and biological factors of environment, such facts can be interpreted with greater assurance of accuracy than is now possible.

ANNOTATED LIST OF SPECIES

AMPHIBIANS

Scaphiopus couchii Baird. Sonoran Spadefoot

A single individual of this spadefoot was dug up July 31, 1930, from a mass of old adobe bricks in an abandoned cistern six miles south of Charleston, a railway station about half way between Fort Huachuca and Tombstone, Cochise County. Two others occurred in a series of toads collected about 9 00 P. M., July 13, 1931, at Willcox.

Scaphiopus hammondii Baird. Western Spadefoot.

Many of these toads were singing in newly-formed rain pools on a salt-grass flat just at the edge of Willcox, Cochise County, July 13, 1931. They were rather widely separated and somewhat shy for they ceased calling when approached, but in most cases retained their positions. Numerous small individuals were found on dry ground between the pools and on a nearby highway.

Bufo alvarius Girard. Giant Toad (fig. 12).

Giant toads were collected in Pima County during August, 1930. The species was seen only in late evening or at night, and all except

Fig 12 The Giant Toad, *Bufo alvarius* Cañada del Oro, twenty miles north of Tucson

one were taken just before or during a thunderstorm. One wandered into camp the night of August 5; three were in a sandy road near the Santa Cruz River on August 6, and three were found among clumps of grass on August 7. All of these localities are in the Cañada del Oro, twenty miles north of Tucson. A single specimen was taken at Well No. 1, six miles northeast of Ajo on August 14.

Bufo cognatus cognatus Sav. Great Plains Toad.

Three specimens were taken in a sandy road at night August 6, 1930, near the Santa Cruz River, sixteen miles north of Tucson, and two were obtained at Willcox, July 13, 1931.

Bufo punctatus Baird and Girard. Red-spotted Toad.

In the Huachuca Mountains a toad of this species was taken July 19, 1930, in the dry creek bed of Carr Cañon at an elevation of about 5300 feet. Another was found July 20 at an elevation of 7600 feet on the north side of Carr Peak. The latter was beneath a stone near Carr Cañon Creek. Three were obtained August 4 near a creek on the west side of the Santa Catalina Mountains, twenty miles north of Tucson. In 1931 this species was collected only at Tinajas Altas, Yuma County, August 25 and 27. It was found in considerable numbers in and around the edge of the lowest rock tank.

Bufo woodhousii Girard. Rocky Mountain Toad.

Specimens of this toad were taken at night in the lower end of Carr Cañon, Huachuca Mountains, on July 20 and 24, 1930. Two others were found in early afternoon beneath a pile of boards near a shed in Sulphur Springs Valley, ten miles southeast of Willcox, July 19, 1931.

Hyla arenicolor Cope. Sonoran Tree Frog.

We first met this species in the Cañada del Oro, August 2, 1930, when two were found about noon on the shady side of small boulders in the creek. The temperature indicated by a thermometer suspended beneath a mesquite tree was 106°F. That evening about 9:00 o'clock several of these frogs sang at various points along the watercourse until our searching disturbed them. Those observed were on the bank at the edge of the water or on boulders in the creek. Two days later more were found on rocks along another creek near the Catalina Mountains on the east side of Cañada del Oro.

On August 6, a series of seventeen was obtained in Cañada del Oro between 7:00 A. M. and noon. Although they often occurred in very dry situations, none were at any great distance from the water.

A space protected from the sun between two large boulders contained six. Heavy local showers during the preceding forty-eight hours had caused a marked rise in the stream level and may have brought the frogs out of more secure hiding places.

In the Huachuca Mountains, July 10, 1931, the day following the first heavy rain of the season, two tree frogs were found in a dry crevice on a high cliff nearly 300 feet above Ramsey Cañon Creek. Two days later three were collected on large boulders in the stream at the bottom of the cañon. Later in the season, September 3, one was found on a wet rock wall in Ramsey Cañon. Another was obtained in the Chiricahua Mountains at an elevation of 6500 feet on Turkey Creek, August 20.

Rana pipiens Schreber. Leopard Frog.

Leopard frogs were taken August 4 and 8, 1930, in a creek between the Cañada del Oro and the Catalina Mountains, twenty miles north of Tucson, and on the night of July 13, 1931, in rain pools of a salt-grass flat at Willcox.

LIZARDS

Coleonyx variegatus (Baird). Banded Gecko.

A specimen of this little gecko taken near Tucson was presented to us by Dr. C. L. Vorhies of the University of Arizona.

Dipso-saurus dorsalis dorsalis (Baird and Girard). Crested Lizard.

These large lizards, found among the sparse growths of creosote bush, mesquite, and cholla, represented the most conspicuous species of western Pima and southern Yuma Counties. When alarmed they took refuge in mammal burrows which seemed always at hand in the sides of the mounds formed where the vegetation anchors the surface soil. Most published accounts of this species associate it with a loose sand habitat. Such areas are not abundant in the vicinity of Ajo where the soil, although sandy, is rather hard packed, and yet we found these lizards very numerous. In the Lechuguilla Desert near Tinajas Altas when the temperature in the shade of the mountain was 108°F. toward midafternoon, they were the only reptiles that were under no cover, except for the scant shade of the creosote bushes under which they crouched.

Compared with other species of the same region, these lizards were very shy and alert to approaching danger. On foot it was almost impossible to approach them within the effective range of a 10-inch .22

caliber collecting pistol, although they could often be shot from the car. A 9 mm. shotgun with a special load of dust shot was effective up to about twenty yards. The best success in collecting this species, however, was by the use of a smooth-bore .22 caliber repeating rifle with a 22-inch barrel. This had the advantage of greater economy and was effective at a greater distance than the 9 mm. shotgun. For collecting in open country where some of the lizards are extremely wary, such an arm was found to be an ideal supplement to the usual 10-inch smooth-bore pistol.

Fifty-two specimens of *Dipso-saurus* were collected during the month of August, 1930 and 1931, in the following localities: PIMA COUNTY: ten miles east of Ajo; Well No. 1, six miles northeast of Ajo; five miles southwest of Ajo; Bates Well, twenty-one miles southwest of Ajo; five miles north of Ajo. YUMA COUNTY: Lechuguilla Desert, east of Gila Mountains between Wellton and Tinajas Altas; near Coyote Water, six miles east of Tinajas Altas. MOHAVE COUNTY: one mile north of Topock.

Crotaphytus collaris baileyi (Stejneger). Western Collared Lizard.

A collared lizard received from Mr. Sanders was taken in Maricopa County at Cañon Lake on the Salt River, seven miles north of Superstition Mountain.

Crotaphytus wislizenii Baird and Girard. Leopard Lizard.

The leopard lizard occurred in the same lowland desert country as *Dipso-saurus d. dorsalis* but much less abundantly. It was also shy and very difficult to approach. Individuals were seldom seen more than a foot or two from the entrance of a burrow into which they usually would dash before one could approach within pistol range. Most of those secured were shot from the car.

One specimen was taken at Well No. 1, six miles northeast of Ajo, Pima County, August 14, 1930. Six were collected August 28 and 30, 1931, in the Lechuguilla Desert between Tinajas Altas and Wellton, Yuma County.

Sauromalus obesus (Baird). Chuck-walla.

One collected at Tinajas Altas, Yuma County, is a juvenile individual showing fairly distinct bands on the tail. Mr. Sanders has sent specimens from Cottonwood Creek, twenty miles northeast of Mesa; from Superstition Mountain, Pinal County, twenty-seven miles east of Mesa; and from the Salt River Valley, seven miles north of Superstition Mountain, Maricopa County. For this species these are the easternmost records that I have been able to obtain.

Callisaurus draconoides ventralis (Hallowell). Desert Gridiron-tailed Lizard.

This species was most frequently met in sandy arroyos bordered with mesquite. It was active from early morning until about 10:00 A. M. and again from late afternoon until dark. Some were taken during the hottest part of the day, however, and at 10:00 P. M. on a cloudy night, August 28, 1931, the lights of the automobile revealed two in a sandy arroyo near Tinajas Altas. While most frequently seen in open sandy areas, it was often observed resting upon boulders or running with great speed between clumps of vegetation. One was seen in the top of a dead cholla.

When quiet and viewed from the rear this lizard is practically indistinguishable against the sand, but when perched upon a boulder, raising and lowering its body by means of its forelegs and waving its tail over its back, it is very conspicuous; the blue and black side markings of the males, and the contrasting black and white ventral tail pattern, are displayed effectively. Although I watched this performance several times I saw no spreading of the throat fan. This addition to such display behavior may be restricted to the time of prenuptial activities earlier in the season. Young individuals almost invariably waved their tails in the air when startled. These revealing movements seemed to be an alarm reaction rather than a display performance.

Localities: PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson; desert eighteen miles west of Tucson; Well No. 1, six miles northeast of Ajo; Growler Pass, between Ajo and Bates Well. PINAL COUNTY: In highway, thirty miles north of Tucson. YUMA COUNTY: Lechuguilla Desert between Wellton and Tinajas Altas; near International Boundary, five miles south of Tinajas Altas; five miles east of Yuma.

Linsdale (1932, p. 359) has pointed out some of the problems in the taxonomy of this group. The genus is still in need of thorough study, however, and until a better understanding of the forms *gabbii* and *ventralis* is reached the latter name may be applied to the Arizona specimens of this collection.

Holbrookia elegans Bocourt Mexican Earless Lizard.

Two Holbrookias which agree with Schmidt's diagnosis of this form (1922, p. 715) were taken August 3, 1930, in the cholla-sahuaro-ocotilla desert of the Cañada del Oro, twenty miles north of Tucson.

Holbrookia maculata approximans Baird. Western Earless Lizard.

Our collections of *Holbrookia* tend to confirm the distinctness of

the short-tailed, tubercular-scaled lowland form (*H. m. approximans*) from the long-tailed, flat-scaled form (*H. pulchra*) of higher altitudes as determined by Schmidt (*loc. cit.*, p. 717). All of our specimens of *approximans* from the vicinity of the Huachuca Mountains were taken below 5000 ft.

Localities. COCHISE COUNTY: Mouth of Carr Cañon, lower end of Montezuma Cañon, flat between lower ends of Carr and Ramsey Cañons, Huachuca Mountains; Willcox; Sulphur Springs Valley, twenty miles south of Dos Cabezas. PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson.

Holbrookia pulchra Schmidt. Huachuca Mountain Earless Lizard.

We collected this species in July, 1931, on the Carr Cañon side of Carr Peak at an elevation of between 5500 and 6000 feet. This is the type locality (Schmidt, 1921, p. 1) although a somewhat higher elevation. The species was more abundant than the series collected would indicate for these lizards were very shy, often seeking shelter in deep crevices or beneath large boulders. They seemed more alert and more swift of movement that the *approximans* of the plain.

Holbrookia texana (Troschel). Band-tailed Earless Lizard.

In the sahuaro-ocotillo desert of the Cañada del Oro, we found this species associated with *Callisaurus draconoides ventralis* to which it bears considerable resemblance. It was not as abundant as the latter, however, and even more wary.

Localities. COCHISE COUNTY: Mesquite flats of the San Pedro Valley, five miles east of Hereford; Charleston, thirteen miles north of Hereford; twenty-five miles west of Willcox. PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson. PINAL COUNTY: Campo Bonito, five miles southeast of Oracle.

Uta graciosa (Hallowell). Long-tailed Uta.

One specimen was taken on a dead mesquite log at Well No. 1, six miles northeast of Ajo, Pima County, August 15, 1930.

As the eastern limit of the distribution of this species has hitherto apparently been the valley of the Colorado River (Van Denburgh, 1922, p. 214), the Ajo record extends the known range approximately a hundred miles to the eastward.

Uta ornata symmetrica Baird. Arizona Tree Uta.

We found tree Utas in every locality in which any considerable amount of collecting was done except in the extreme western portion

of the area included in this paper. They occurred at elevations ranging from the desert basins under 500 feet near Ajo to an altitude of over 8000 feet on Carr Peak in the Huachuca Mountains, and in a great variety of habitat associations. The great majority of our large series was taken on rocks and trees but occasionally they were seen on the ground, both in the open and among bushes. Two were found among boards and other debris near abandoned buildings In the mountains or along boulder-strewn creek beds they were almost always on rocks, in crevices or on the side of a cliff. When in the foothills or lowlands, however, they occurred on the trunks and branches of the oaks or mesquite. We did not observe them associated with any of the cacti but Ortenburger (1926, p. 106) found several on dead cholla in the Cañada del Oro region.

In 1930, between July 19 and August 1, this species was common in all localities visited in the Huachuca Mountains but in 1931, between July 5 and 13, it was very scarce in this locality. Only two specimens were obtained during the second season. This difference in abundance may be accounted for by the fact that the summer rainy season was well under way at the time of our first visit, but when we were there the following year the rains were just beginning.

Localities. COCHISE COUNTY: Carr Cañon, Carr Peak, Montezuma and Ramsey Cañons, Huachuca Mountains; foothills of the Chiricahua Mountains, twenty miles southeast of Dos Cabezas; Turkey Creek Ranger Station, Chiricahua Mountains, thirty miles southeast of Dos Cabezas; San Pedro Valley, ten miles east of Fort Huachuca. PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson; foothills of the Catalina Mountains, twenty-two miles north of Tucson; Well No. 1, six miles northeast of Ajo; Growler Pass, near Bates Well, twenty miles southwest of Ajo. PINAL COUNTY: Campo Bonito, five miles southeast of Oracle; 3 miles west of Superior (Sanders).

Uta stansburiana stejnegeri Schmidt. Southern Brown-shouldered Uta.

Our observations and collections indicate that this subspecies is restricted to the lower foothills and open deserts but not entirely to rocky areas since it was taken in the loose sand country east of Yuma and in the vicinity of Ajo. Although it was perhaps more abundant in rocky places it was found on the ground under bushes, in the branches of mesquite and creosote bush, beneath fallen sahuaros, and running in the open desert trails. It was one of the most common reptiles at Tinajas Altas and on the floor of the Lechuguilla Desert. In that region it usually was more active toward evening than in the early morning and during the very hot part of the day was not mov-

ing about at all. On August 29, 1931, a heavy local storm gave the Tinajas Mountains and adjacent desert a terrific drenching which lasted almost an hour. Within half an hour after the rain stopped, before the sun was again revealed, these Utas came out of their shelters and played about on the wet granite in greater numbers than were seen at any other time.

Localities. PIMA COUNTY: Well No. 1, six miles northeast of Ajo; between Ajo and Bates Well, sixteen miles southwest of Ajo. YUMA COUNTY: Gila Valley, five miles east of Yuma; Ligurta, twenty-four miles east of Yuma; Lechuguilla Desert between Wellton and Tinajas Altas, Tinajas Altas. MARICOPA COUNTY: Mesa (Sanders). We did not find this species in the Tucson region but it was collected there by Ortenburger (1926, p. 107).

Sceloporus clarkii clarkii Baird and Girard. Arizona Scaly Lizard.

That this lizard is in the main a tree-frequenting species has been indicated by Ruthven (1907, p. 538), Van Denburgh (1922, vol 1, p. 363), and others. In the Huachuca Mountains we found it almost always in trees but in the Cañada del Oro usually on or among rocks or on the ground. Of our entire series for both seasons fourteen were found on rocks or in crevices, six were in trees, five were on abandoned buildings and two on the ground. All specimens were taken at low elevations in the foothills and cañon mouths or along the arroyos on the plain.

Localities. COCHISE COUNTY: six miles north of Bisbee; Ash, Carr, and Montezuma Cañons, Huachuca Mountains; plain west of the Chiricahua Mountains, eighteen to twenty miles southeast of Dos Cabezas; "Circle J" Hills, eight miles north of Willcox; San Pedro Valley near Fairbank. PIMA COUNTY: Cañada del Oro and foothills of the Catalina Mountains eighteen to twenty miles north of Tucson PINAL COUNTY: Campo Bonito, five miles southeast of Oracle.

Sceloporus jarrovii jarrovii Cope Yarrow's Scaly Lizard.

At altitudes above 5000 feet in the Huachuca and Chiricahua Mountains Yarrow's *Sceloporus* was by far the most abundant reptile. It occurred in almost every type of habitat: on the walls and ledges of cliffs, in crevices, on rocks along the brooks, in rock slides, on trees, fallen logs, abandoned buildings, in heaps of debris and old machinery parts, beneath piles of boards, and on the ground.

On clear days it was nearly always encountered in sunny spots along the trails, the brilliant bluish color of the older individuals making them very conspicuous. On cloudy days or in the early morning it was not so much in evidence but sluggish individuals of a dull

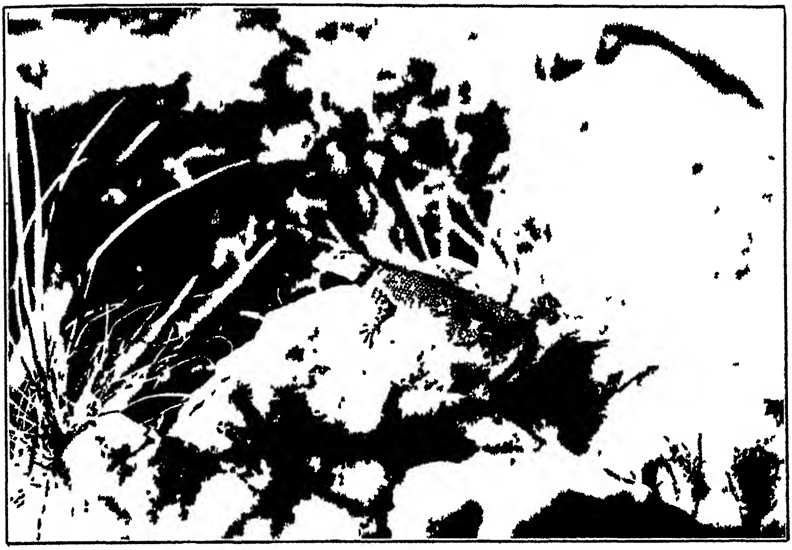

Fig 13 Yarrow's Scaly Lizard, *Sceloporus jarrovii* Ramsey Cañon Huachuca Mountains This is probably the most abundant reptile in the mountains of southeastern Arizona

coloration were found beneath loose bark on logs, under stone piles or amid rubbish. Stejneger (1902, p. 151) noted that a marked color change, apparently due to temperature, occurs in this species. This phenomenon, from our observations, occurs only in older individuals and is more accentuated in males than in females. The young are dull colored with no blue except for a pale throat patch.

Because of their lack of timidity and great curiosity these lizards were easily captured by means of a thread noose at the end of a slender stick. When approached with the noose some seized the thread and chewed it savagely, and although somewhat alarmed by attempts to drop the noose over their heads, did not become frightened enough to flee to safety at once but permitted the collector to try again. Those of larger size were more difficult to approach and usually scampered out of reach up the cañon wall if the first trial with the loop was unsuccessful.

On July 30, 1930, in a partly dismantled shed in Ash Cañon, Huachuca Mountains, I watched two approximately half grown *S. jarrovii*, one somewhat larger than the other, fighting or pretending to fight. They sprang at each other with open mouths but neither seemed to receive much, if any, injury. After one of these clashes they separated, faced each other, spread their throat fans widely, and each

bobbed rapidly up and down, raising and lowering its body with its forelegs. The larger apparently tired of this activity and turned to other pursuits while the smaller menacingly followed with open mouth.

Remains of this species were found in the excrement of *Crotalus triseriatus pricei* VAN DENBURGH in the Chiricahua Mountains.

Localities. COCHISE COUNTY: Ash, Carr, Miller, Montezuma, and Ramsey Cañons, Huachuca Mountains; Turkey Creek, Bonita and Ward Cañons, Chiricahua Mountains, all above 5000 feet.

Sceloporus magister magister Hallowell. Desert Scaly Lizard.

With the exception of one individual collected among rocks, we found this large *Sceloporus* only on the floor of the desert. As pointed out by Ruthven (1907, p. 534) and Van Denburgh (1922, p. 336) it is a wary species, usually associated with vegetation, and infrequently seen in the open. In the Lechuguilla Desert we often observed it taking refuge in burrows beneath the clumps of creosote bush before we were close enough for an attempt to secure it.

Localities. GILA COUNTY: three miles northwest of Globe (Sanders). MARICOPA COUNTY: Mesa (Sanders). PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson; Well No. 1, six miles northeast of Ajo; Growler Pass, twenty-one miles southwest of Ajo. YUMA COUNTY: Gila Valley, six miles east of Yuma; Lechuguilla Desert, between Wellton and Tinajas Altas.

Sceloporus scalaris Wiegmann. Orange-sided Swift.

According to Van Denburgh (1922, p. 272) this species is known in the United States only from the Santa Rita and Huachuca Mountains of southeastern Arizona. We secured three specimens, all in the month of July, 1930 and 1931, from the latter region in the vicinity of the Hamburg Mine at the upper end of Ramsey Cañon. All were found beneath boards in a clearing.

Sceloporus undulatus consobrinus Baird and Girard. Striped Swift.

Although collected in several localities in the mountains and eastern plains area, this lizard was not commonly seen except on boulders at the sides of the road to the Turkey Creek Ranger Station in the Chiricahua Mountains. Specimens were also taken on trees and buildings and beneath stones.

Localities. COCHISE COUNTY: Turkey Creek and Ward Cañon, Chiricahua Mountains; Montezuma Cañon, Huachuca Mountains; Hereford; Willcox. PINAL COUNTY: Campo Bonito, five miles southeast of Oracle. YAVAPAI COUNTY: twenty-two miles south of Ashfork.

Phrynosoma cornutum (Harlan). Texas Horned Lizard.

Represented in our Arizona collection by a single specimen obtained by Mr. Doudna at Willcox, Cochise County.

Phrynosoma douglassii hernandesi (Girard). Short-horned Horned Lizard.

Three small examples of this form were obtained in a trail on the north side of Carr Peak, Huachuca Mountains, at an elevation of 6000 feet, July 21, 1930. Another was secured between Campo Bonito and the Bonito Mine, 5000 feet, between five and six miles southeast of Oracle, Pinal County, August 12, 1930.

Phrynosoma modestum Girard. Round-tailed Horned Lizard.

Collected by Mr. Doudna near Dos Cabezas, Cochise County.

Phrynosoma platyrhinos Girard. Desert Horned Lizard.

Five specimens were collected in the Lechuguilla Dessert,. Yuma County, between Wellton and Tinajas Altas, August 25 and 28, 1931. They were taken in early morning, late afternoon and after sunset.

Phrynosoma solare Gray Regal Horned Lizard.

We obtained this horned lizard only in open desert where vegetation was sparse. One was taken near an ant hill and excrement voided before it was preserved contained large quantities of the hard parts of these insects.

Localities. PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson; between foothills of the Catalina Mountains, twenty-two miles north of Tucson; Well No. 1, six miles northeast of Ajo; Bates Well, sixteen miles southwest of Ajo.

Gerrhonotus kingii Gray Sonoran Alligator Lizard. (fig. 14).

We found no individuals of this species below 6000 feet and six of the eight obtained were taken at 7000 feet or above. Five were found in open grassy areas, two were under boards, one was found dead at the base of a 300-foot cliff, another seen in Ash Cañon, Huachuca Mountains, escaped among the dead lower leaves of a group of sotol plants. These lizards moved with a deliberateness which gave an impression of much less speed than that actually attained and were difficult to capture alive.

Localities. COCHISE COUNTY: Ramsey Cañon, Huachuca Mountains; Turkey Creek and Ward Cañon, Chiricahua Mountains.

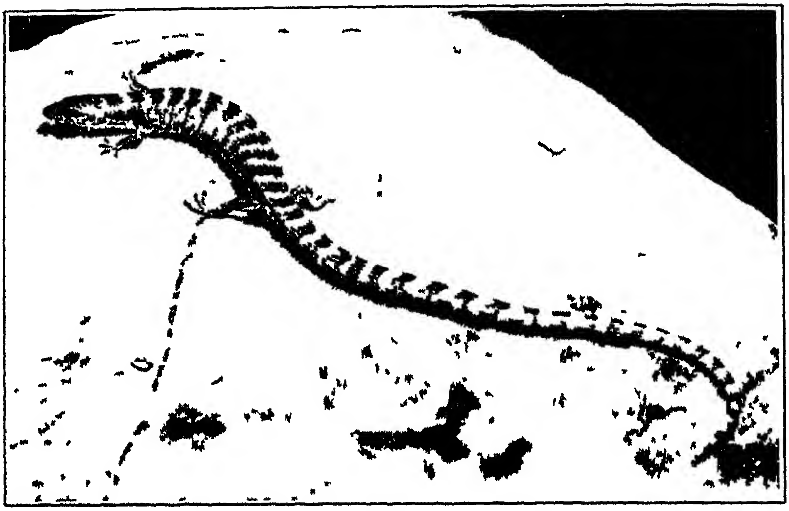

Fig. 14. Sonoran Alligator Lizard, *Gerrhonotus kingii*, a species occurring at elevations above 6000 feet in the mountains of southeastern Arizona.

Heloderma suspectum Cope. Gila Monster.

The Gila Monster was collected in the late evening only, in all cases after sundown. Two were obtained just after a heavy thunder shower. One was found in the mesquite plain of the San Pedro Valley, one on the desert floor near foothills of the Catalina Mountains; another on a rocky ridge in the desert, and a fourth in a sandy arroyo.

Localities: COCHISE COUNTY: San Pedro Valley, ten miles northeast of Fort Huachuca, foothills of Mule Mountains near Don Luis; Sulphur Springs Valley near Gleason (Bowman). PIMA COUNTY: Desert at western edge of the Catalina Mountains, twenty-one miles north of Tucson, west side of Cañada del Oro, eighteen miles north of Tucson.

Cnemidophorus sexlineatus perplexus Baird and Girard. Sonoran Whiptailed Lizard.

The Sonoran "race runner" was one of the most abundant species in the lowland plains and valleys of southeastern Arizona. While it penetrated the cañons of the eastern slope of the Huachuca Mountains it was found only in the cañon floors at elevations below 5000 feet.

In the Huachuca region it was associated with small shrubs and undergrowth, on the plains of the San Pedro Valley mostly with mesquite and creosote bush, near Willcox and Dos Cabezas with desert grass, mesquite and sage brush, and in the Cañada del Oro with chaparral thickets of creosote bush, mesquite, prickly pear and ocotillo.

Extremely large individuals of 200 mm. and greater in length and with a pattern of transverse rows of spots instead of longitudinal stripes were found only in the Cañada del Oro north of Tucson and at Campo Bonito near Oracle. These large examples are regarded by Ruthven (1907, p. 557-559) and by Burt (1931, p. 130) as conspecific with the widely distributed, striped form, and the differences assumed to be due to especially favorable environmental conditions in the Tucson region.

Localities. COCHISE COUNTY: Six miles north of Bisbee; Carr and Montezuma Cañons, Huachuca Mountains; one mile east of the Huachuca Mountains; San Pedro Valley, three miles east of Hereford. PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson; foothills of the Catalina Mountains, east of Cañada del Oro. PINAL COUNTY: Campo Bonito, five miles southeast of Oracle.

Cnemidophorus tessellatus tessellatus (Say). Desert Whip-tailed Lizard.

Although this lizard was abundant in the deserts of Pima and Yuma counties, we took only one specimen in the plains area east of the Huachuca Mountains. It has been recorded, however, from several localities in Cochise County (Burt, 1931, p. 159, 177). To Dr. Burt's excellent summary of the literature on the habitats, behavior and food of this species (*loc. cit.*, p. 188-197) little can be added from our observations. In the Papago Country, however, in the vicinity of Ajo and Tinajas Altas where this species was abundant, we found it quite as frequently in areas of hard-packed soil with numerous mammal burrows as in a loose sand habitat. This seems to indicate that for this lizard loose soil is not an important environmental factor, as some writers have suggested, and supports Burt's statement that this is one of the most plastic of American lizards.

Localities. COCHISE COUNTY: Eight miles north of Willcox. MARICOPA COUNTY: Mesa (Sanders). PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson; on Tucson-Ajo road, forty miles east of Ajo; Well No. 1, six miles northeast of Ajo; five miles southeast of Ajo; Bates Well, sixteen miles southwest of Ajo. YUMA COUNTY: Gila Valley, five to six miles east of Yuma; Lechuguilla Desert, between Wellton and Tinajas Altas; Tinajas Altas; six miles southeast of Tinajas Altas; Wellton.

Eumeces callicephalus Bocourt.

This species has been but recently added to the known fauna of the United States (Taylor, 1929, p. 67-69). We obtained one specimen and saw another at an altitude of about 6400 feet among loose rocks on the north side of Ramsey Cañon (fig. 3), Huachuca Mountains, July 10, 1931. I am indebted to Dr. E. H Taylor of the University of Kansas for the identification of this specimen.

Eumeces obsoletus (Baird and Girard). Sonoran Skink.

During the month of July, 1930, we collected several juvenile specimens of this skink thought to be young of the previous year. They were beneath stones at an elevation of about 5400 feet in Carr Cañon, Huachuca Mountains. One adult and three young were taken in a stone pile near the Wilcox Ranch house, about two and a half miles southeast of the Huachuca Mountains, on July 30, 1930. This was at an elevation of approximately 4600 feet on the plain sloping toward the San Pedro River.

SNAKES

Heterodon nasicus Baird and Girard. Western Hog-nosed Snake.

A small hog-nosed snake was found in sand beneath a piece of tin on the plain east of the Huachuca Mountains, four miles southeast of Fort Huachuca, July 31, 1930. This species was also taken in the Sulphur Springs Valley, twelve miles southwest of Dos Cabezas, July 20, 1931, and at Willcox, August 19, 1931; all in Cochise County.

Masticophis semilineatus (Cope) Sonoran Whip Snake.

Mr. Ditzler took a specimen of this snake in the lower end of Carr Cañon, Huachuca Mountains, July 22, 1930. It was discovered in the open near a creek and when pursued attempted to enter a crevice under a stone; this failing to give it protection, it climbed into the branches of a small tree. Another was taken August 3, and a third August 5, near the stream in the Cañada del Oro, twenty miles north of Tucson. None of these attempted to rely upon their speed in escaping but sought shelter in the nearest cover.

Masticophis flagellum frenatum (Stejneger). Western Whip Snake.

That the subspecies *frenatum* and *flavigularis* of *Masticophis flagellum* intergrade in southeastern Arizona and southwestern New Mexico has been indicated by Ortenburger in his monograph of the genus (1928, p. 124 and 146). At the time in which his studies were

made, however, very little material from this region was available. Two of our specimens from Cochise County, Arizona (U.M.M.Z. 69668 and 71340), show intergradation in color pattern between these two forms. For comparison of these intermediate specimens with more typical examples of the two subspecies from localities fairly close to the region of intergradation, notes on certain characters are given in table V.

TABLE V. Comparison of Certain Characters in Specimens of *Masticophis flagellum frenatum* and *M. f. flavigularis.*

Specimen	Ventrals	Caudals	General colo tone in life	White stripe on loreal	Ventral Pattern	Neck Bands
flavigularis UMMZ No 69667 ♀ Brewster Co., Texas	198	109	pinkish	—	Very indistinct, brownish, more than 8, fading posteriorly, 1-2 scales wide, separated by 2-4 rows of scales of ground color	Thoat heavily blotched with brown, double rows of spots forming 2 longitudinal stripes on anterior fourth of belly
Intermediate toward *frenatum* UMMZ No 71340 ♀ 20 miles southeast of Dos Cabezas, Ariz.	199	106	red	—	Indistinct, reddish brown, about 8, first 4 more conspicuous	Faintly and irregularly blotched with reddish brown on throat and first 30 ventrals
Intermediate toward *frenatum* UMMZ No 69668 8 miles north of Hereford, Arizona.	193	82+	brown	+	Indistinct, brownish, 8-10, fading posteriorly, 2-4 scales wide, separated by 1-scale areas of ground color	Distinctly but irregularly blotched with brown on throat and anterior fourth of belly
frenatum UMMZ No 69669 ♂ 20 miles north of Tucson, Arizona	194	92+	brown	+	Very conspicuous, black; 3-5 in number, followed by 4-5 less distinct, brownish bands	Irregular distinct black blotches on throat and anterior fourth of belly

In scutellation these specimens are within the range of variation described by Ortenburger for *flavigularis* in New Mexico and *frenatus* in Arizona. In number of ventrals one (71340) with 199 exceeds the mean (195) for *flavigularis* in New Mexico, while the other (69668) with 193 is close to the mean (194) for Arizona specimens of *frenatum*.

In life the general color tone of No. 71340 was red, approximating that of a red-phase *frenatum* described by Ortenburger (*loc. cit.*, p.

114).* The other was generally brownish, the lateral and dorsal scales with a median dark line which gave the impression of a series of narrow longitudinal stripes more conspicuous laterally. This coloration was noted by Ortenburger (*loc. cit.*, p. 103) in a *flavigularis* from Las Cruces, New Mexico, and in four other specimens from Chihuahua, Durango, and San Luis Potosi, Mexico. Another character in which the Arizona specimens show intergradation is in the loreal white stripe which is present in typical *frenatum* but absent in *flavigularis*. This loreal stripe is possessed by No. 69668 but is lacking in No. 71340. Neither of the intermediates has the black crossbands on the neck typical of *frenatum* although this pattern is approached in No. 71340 by four reddish-brown neck bands of the same shape and position of those of the usual black pattern. Both have a ventral coloration similar to that most commonly found in *frenatum*.

These intermediate specimens furnish definite indications of intergradation between *flavigularis* and *frenatum* in southeastern Arizona. Individuals from southwestern New Mexico should be expected to show a somewhat stronger tendency toward *flavigularis*.

During the afternoon and evening of July 30, 1930, a heavy rain washed out portions of the bank of a highway drainage ditch about three miles east of the Huachuca Mountains. The following morning while repairing the damaged road, Mr. Leslie Wilcox of Hereford discovered a snake egg in the ditch. In the edge of the bank above, eleven inches beneath the surface of the ground, were seven more. They were in a compact mass, not adhering to one another, and all somewhat discolored from contact with the reddish-brown soil. One that was injured contained a young snake about ten inches long. They appeared spoiled a week later and when opened all young were dead. Dark neck bands typical of *frenatum* could be distinguished in some but the pigmentation was not sufficiently developed to determine whether or not any showed evidence of intergradation with *flavigularis*.

The *frenatum-flavigularis* intergrades above described were taken in the following localities in Cochise County: U. M. M. Z. No. 69668, in an abandoned cistern among trash and a pile of adobe bricks, San Pedro Valley, eight miles north of Hereford; No. 71340, coiled within the cavity of a gas engine piston in a ranch building, Sulphur Springs

* That a similar red phase sometimes occurs in *flavigularis* seems not to be generally known. Ortenburger does not mention it either in his description or discussion of that form. A specimen collected by the writer near Pueblo, Colorado (U.M.M.Z. 71787), was decidedly red above and pink below in life. Its color pattern resembled the form with wide dark crossbands ten to fifteen scales in width (Ortenburger, 1928, p. 94), although each of these wide bands was broken up into two to four (usually three) narrow bands separated by two to four scales of ground color. The cross bands were reddish-brown and did not exhibit great contrast with the intervening areas. Ventrally there were two fairly regular red stripes on the anterior third of the body.

Valley, twenty miles southeast of Dos Cabezas. An adult *frenatum* with normal pattern (U. M. M. Z. 69669) was captured August 8, 1930, in the desert near the foothills of the Catalina Mountains, Pima County, twenty miles north of Tucson. A juvenal specimen was taken August 28, 1931, in the Lechuguilla Desert between Tinajas Altas and Wellton, Yuma County, beneath a tangle of prickly pear and creosote bush. A specimen later received was taken at Mesa, Maricopa County (Sanders).

Masticophis piceus (Cope). Black Whip Snake.

Only one specimen of the black whip snake was obtained. It was collected in the Cañada del Oro, eighteen miles north of Tucson, Pima County, August 5, 1930. Another was seen in the same region.

Salvadora grahamiae hexalepis (Cope). Western Patch-nosed Snake.

A small patch-nosed snake, hit by an auto but little damaged, was found in a sandy road on the plain six miles northwest of Hereford, Cochise County, July 26, 1930. Two were collected in an arroyo eight miles northwest of Hereford, July 31, 1930. Both of these traveled over an open stretch of sand with great swiftness. They fought valiantly when captured, striking repeatedly and vigorously. The taking of these specimens about sundown seems to indicate crepuscular or nocturnal habits in this species. Van Denburgh (1922, p. 692) tells of one found partly buried in the sand.

Pituophis sayi affinis Hallowell. Arizona Gopher Snake.

Of a total of fourteen specimens of this form twelve were taken in the southeastern portion of the state. Those found active in the open were collected early in the morning, in the late afternoon or at night. Only two were secured during the hot part of the day and these were under cover. Raking through the pile of brush and cholla joints of a wood rat's house disclosed a gopher snake snugly coiled within the nest. It later disgorged a partially digested *Neotoma*. Another was in an abandoned cistern beneath a pile of debris. With the exception of one taken at an elevation of about 6000 feet in Ash Cañon, Huachuca Mountains, this species was found only in the lowland plains or deserts, and often in or near highways or little-used roads. This appears to be a very inoffensive snake for none seemed to resent capture or handling.

Localities. COCHISE COUNTY: Ash Cañon, Huachuca Mountains; San Pedro Valley, two miles east of Benson; two miles south of Fairbank; five miles southeast of Fort Huachuca; ten miles east of Fort

Huachuca, thirteen miles north of Tombstone; Sulphur Springs Valley, three miles west of Dos Cabezas; twelve miles southeast of Dos Cabezas; ten miles southeast of Willcox. MARICOPA COUNTY: Seven miles east of Mesa (Sanders). PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson. YUMA COUNTY: Lechuguilla Desert, fifteen miles south of Wellton.

Lampropeltis getulus splendida (Baird and Girard). Sonoran King Snake.

A king snake fairly typical of this subspecies was found beneath a pile of boards at the "Circle J" Ranch, ten miles southeast of Willcox, July 19, 1931. Mr. Doudna saw another, thought to be this form, at Willcox.

Lampropeltis getulus yumensis Blanchard. Desert King Snake.

In the western foothills of the Catalina Mountains during the late evening of August 3, 1930, a specimen of this king snake was found among the underbrush of mesquite and catclaw near a small group of cottonwoods at the mouth of a little cañon. The locality is about twenty-three miles north of Tucson on the eastern side of the Cañada del Oro, Pima County. Another was collected, also in the late evening, in the Gila Valley six miles east of Yuma, Yuma County, August 21, 1930.

The Tucson specimen has unusually wide cream-colored bands on an almost black ground color. The crossbands of the one from Yuma are relatively much narrower and less conspicuous and the ground color is dark fuscous rather than black.

Lampropeltis pyromelana (Cope). Arizona King Snake.

This brilliantly colored species was encountered only at high elevations in the Huachuca Mountains. Six specimens, nearly all of which were in the open among rocks on the cañon sides or in the trails, were secured. One was entwined in the lower branches of a small mountain mahogany shrub (*Cercocarpus*) its red, black and cream-colored bands making a striking picture against the smooth red bark with yellowish leaf scars. A large individual seen in a trail in Ash Cañon escaped in a nearby rock slide.

Localities. COCHISE COUNTY: Carr, Ramsey, and Miller Cañons, Huachuca Mountains. PIMA COUNTY: Stratton Cañon, Santa Catalina Mountains, July 29, 1932 (Painter).

Sonora occipitalis (Hallowell). Tricolored Ground Snake.

Our only representative of this secretive little snake was taken

about 9:30 P. M. in the soft sand ridges of the Gila Valley, five miles east of Yuma. Sand trails likely to have been made by this species were much in evidence.

Thamnophis eques (Reuss). White-bellied Garter Snake.

We found this garter snake usually in the near vicinity of water, sometimes swimming in the creeks. An exceptional case was the discovery of one beneath a creosote bush on the dry plain of the San Pedro Valley at least two miles from water.

Localities. COCHISE COUNTY: Carr and Ramsay Cañons, Huachuca Mountains; San Pedro Valley, two miles east of Hereford; Sulphur Springs Valley, eighteen to twenty miles southeast of Dos Cabezas. GILA COUNTY: ten miles north of Payson (Sanders). PIMA COUNTY: Cañada del Oro, eighteen to twenty-two miles north of Tucson.

Thamnophis marcianus (Baird and Girard). Marcy's Garter Snake.

Specimens from Mesa, Maricopa County, were received from Mr. Sanders.

Thamnophis megalops (Kennicott).

Specimens were sent from Mesa by Mr. Sanders who states that this species is not common in that area.

Trimorphodon lyrophanes (Cope). Arizona Lyre Snake.

A specimen collected by Dr. Smith eighteen miles southwest of Ajo (two miles west of Bates Well), Pima County, extends the known range in Arizona some distance westward. It was in a crevice of rock just within the entrance of an abandoned "prospect" on a low granite ridge.

Micruroides euryxanthus (Kennicott). Sonoran Coral Snake.

Mr. Philip Blossom of the University of Michigan Museum of Zoology collected a coral snake in the Agua Dulce Mountains, seven miles east of Papago Well, Pima County, May 17, 1933. It failed to show resentment when carelessly handled by a prospector who insisted that it was a "harmless garter snake."

Crotalus cinereous LeConte. Western Diamond Rattlesnake.

About 8:30 A. M. on July 31, 1930, Mr. Ditzler discovered a rattlesnake of this species in a sheltered recess among limestone rocks near the mouth of Carr Cañon, Huachuca Mountains. As I hurried toward him with a camera, he noticed three small groups of newly-born young coiled within a few inches of the mother. During the

operations involved in setting up a tripod, the little snakes became alarmed and one by one disappeared under the rocks. We did not attempt to restrain them for fear of disturbing the mother who obligingly kept her position, giving only an occasional admonitory buzz, while several exposures were made (fig. 15). We bagged the large snake and moved the rocks in search of the young. They all had entered a short, pocket-like burrow in the ground and the eight secured are thought to be the entire brood. The female (U.M.M.Z. 69736) measured 935 mm. The measurements of the young follow:

	Sex	Total length	Tail length
(1)	♂	280 mm	25 mm
(2)	♀	293	21
(3)	♀	295	21
(4)	♂	290	25
(5)	♀	287	21
(6)	♀	288	19
(7)	♀	301	22
(8)	♂	295	25

Another female taken August 3, 1931, by Mr. Doudna near the Dragoon Mountains, thirty miles southwest of Willcox, gave birth to young the following night or next day.

To the good fortune of the collector, snakes sometimes become trapped in smooth-sided excavations, such as ditches, tanks, reservoirs, etc. Such a fortuitous trap was formed by an abandoned cistern in the San Pedro Valley, eight miles north of Hereford. It contained an accumulation of tin cans, corrugated iron, scraps of lumber and a pile of disintegrating adobe bricks. When several stones had been tossed into the pile, the characteristic buzz revealed the presence of a rattle-snake. After considerable digging a medium-sized *cinereous* was uncovered, together with a whip snake, gopher snake and spadefoot toad already mentioned.

Three specimens of *Crotalus cinereous* from southeastern Arizona and southwestern New Mexico exhibit a peculiar pink or reddish coloration, comparable to that of light colored examples of *Crotalus ruber* in southern California. An unusually high degree of erythrism was manifest in a *cinereous* found dead on the highway four miles northeast of Douglas, Arizona, where the soil of the surrounding country is of a reddish brown color. In this individual the head was gray with no conspicuous stripes on the cheeks, the supralabials, infralabials, chin and throat white. The dorsal ground color was salmon pink, deeper in tone posteriorly and increasing in brilliance on the sides. The outer ends of the ventrals showed a decided tinge of pink

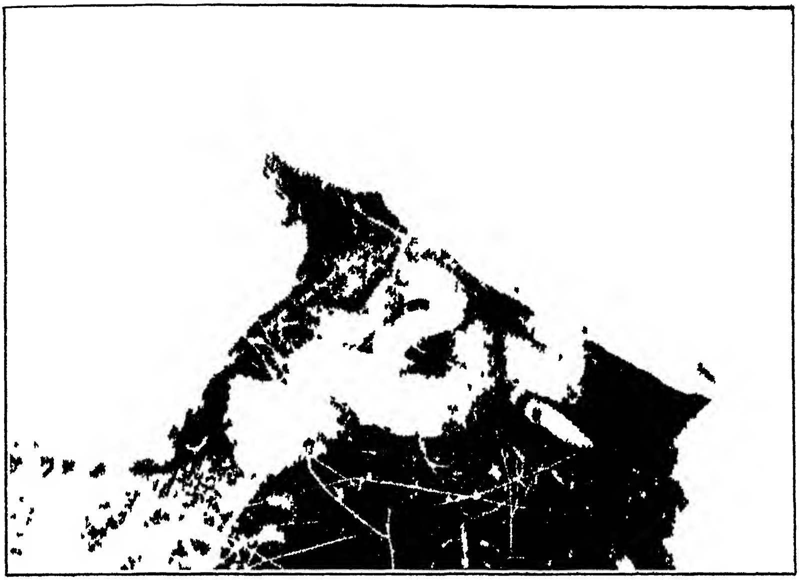

Fig. 15. Western Diamond Rattlesnake, *Crotalus cinereous*, in lower Carr Cañon, Huachuca Mountains. Eight newly born young found with this female sought refuge under the rocks.

throughout the length. The dorsal blotches were reddish-brown, not conspicuously distinct, and posteriorly blended almost completely with the ground color. On the anterior half of the body the blotches were separated by short, indistinct white crossbars, the white restricted to the tips of the scales of the five or six median rows. These white bars became darker posteriorly and disappeared entirely on the caudal third of the body. The median portion of the belly was cream color, the ventral side of the tail suffused with pink.

Another specimen taken seven miles north of Willcox shows the same type of coloration but there are traces of stripes on the sides of the head, the dorsal blotches are more distinct, more brown, have white borders both medially and laterally, and toward the tail form cross-bands of a deeper tone than that of the ground color. The third specimen of this type was collected by Malcolm V. Parker in the vicinity of Red Mountain, ten miles southwest of Deming, New Mexico. It differs from the two just described chiefly in that there are no white scales separating the dorsal blotches.

Since individuals with the gray coloration usual for *Crotalus cincreous* have been obtained from the same or nearby localities, the significance of erythrism in this species is not clear.

These rattlesnakes seemed to be abroad in the open only in the late evening and after nightfall. Several were caught crossing roads or trails on the plain between sundown and dark. Some were found among boulders near the foothills but none were taken at elevations above 5000 feet.

Localities. COCHISE COUNTY: San Pedro Valley, opposite Carr Cañon, Huachuca Mountains, ten miles west of Hereford; eight miles north of Hereford; two miles south of Fairbank; Sulphur Springs Valley, "Circle J" Hills, eight miles north of Willcox; mesquite flats seven miles north of Willcox; foothills of Dragoon Mountains, thirty miles southwest of Willcox, four miles northeast of Douglas. GILA COUNTY: three miles northwest of Globe; six miles east of Sacaton; fifteen miles south of Payson (Sanders). MARICOPA COUNTY: Gillespie Dam; eight miles northeast of Mesa; twelve miles east of Mesa (Sanders). PIMA COUNTY Cañada del Oro, twenty-one miles north of Tucson.

Crotalus cerastes Hallowell Sidewinder; Horned Rattlesnake.

As we were within the range of the sidewinder only in the late summer night collecting was most effective. We saw none during the day. One found between sundown and dark was coiled on the top

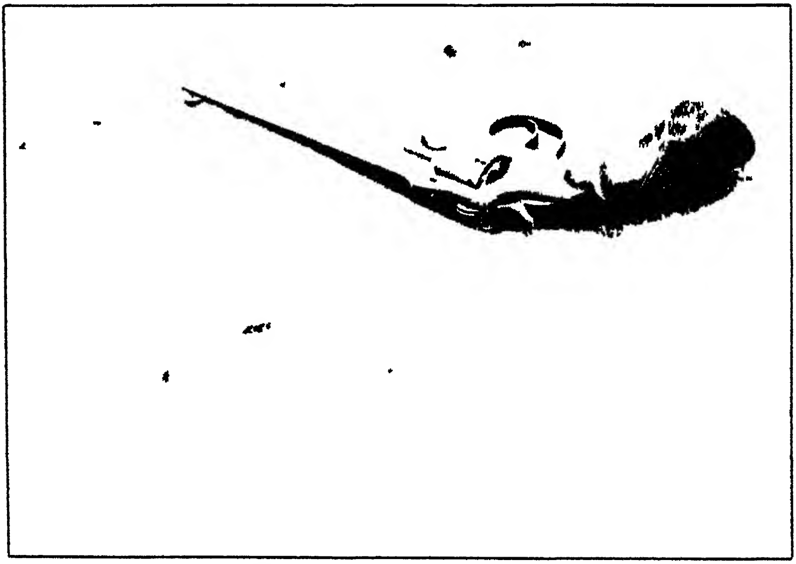

Fig 16 The imprint made by a Sidewinder, *Crotalus cerastes* coiled in soft sand Gila Valley six miles east of Yuma

Fig. 17. Daytime shelter of a Sidewinder, *Crotalus cerastes*, in the Gila Valley east of Yuma. Note trail leading to the base of the creosote bush on top of the mound (see page 126)

of a sandy mound amid the branches of a creosote bush. When touched with a collecting hook it sprang off the mound and across an open space between bushes at a surprising speed. Another met at night in the road near Growler Pass made no effort to escape.

In the soft sand ridges near the Gila River east of Yuma we frequently saw circular imprints made by a snake coiled in the sand (fig. 16). A sidewinder was discovered one night in such a location. Its compact coil was more than half buried. When first observed it was swinging its head slowly from side to side. Presently it opened its mouth in a wide yawn, erecting its fangs alternately with a stretching motion, just as captive snakes have been observed to do soon after eating. When it was captured no enlargement of the stomach indicated a recent meal but it seems probable that unwary nocturnal mammals may be captured by snakes from such a position of apparent repose. It is unlikely that rattlesnakes engage in active, rapid pursuit of prey. Such behavior in capturing swiftly moving mice or lizards would necessitate a high degree of skill, speed, and a constancy of purpose which they give no indication of possessing. On the contrary, they seem to depend upon the random wanderings of themselves and their prey to bring them within striking distance.

Fig 18 The inhabitant of the burrow shown in figure 17 a flashlight photograph made about 9 45 P M

The possibilities of night photography were suggested by the finding of sidewinders in the manner described and on subsequent trips a camera and flashlight apparatus were added to the usual equipment. On the morning of August 20, 1930, the daytime abode of a sidewinder was located. From the entrance of a burrow in a mound beneath a creosote bush, a very definite sand trail led to the top of the mound (fig. 17). Here it ended in a circular imprint such as those seen in the open sand areas. No trails led down on the other side nor were there any other snake tracks from the entrance of the burrow. The trail from the opening to the summit of the mound had several tracks partly superimposed upon each other, as if the snake had during several successive nights crawled to the top of the mound, passed the night in a comfortable coil, and returned by the same path. We marked the spot with a handkerchief tied to a bush and returned at 9:30 P. M. A new track showed conspicuously on the trail we had examined. This time, however, it led on across the top of the mound, down the other side and across the open sand. Less than thirty yards distant, at the side of a bush, the snake was located. It showed little excitement and remained quiet while the camera was set up and our desire to make a night photograph of this species in its desert habitat was gratified (fig. 18).

In the vicinity of Tinajas Altas in late August, 1931, we did not find this species. Since the region is similar to that of Ajo and Bates Well where we secured sidewinders the previous year, it should be expected to occur, although perhaps less abundantly than in the soft sand dunes and ridges of the Gila and Colorado Valleys. Mr. R. Hale and Mr. O. D. Herron, who operate an auto service station and reptile exhibit known as "Reptile Inn" on the highway between Wellton and Mohawk, told us that sidewinders are abundant in that region. A series purchased from them exhibits a considerable variation in color tone, some having a much darker shade of brown than others. One that we saw in captivity twenty-eight miles east of Gila Bend was unusually dark. Those in our own collection from Ajo where the soil is dark brown were noticeably darker than those from the light colored sandy areas near Yuma. However, as Klauber has recently pointed out (1931, p. 46), this is one of the few snakes in which the color tone apparently varies with changes in the physiological condition of the individual, and differences in intensity of coloration in different regions may have little significance.

Localities. MARICOPA COUNTY: twenty-eight miles east of Gila Bend; ten miles east of Mesa (Sanders). PIMA COUNTY: Well No. 1, six miles northeast of Ajo; Growler Pass, eleven miles southwest of Ajo, twenty-five miles east of Tule Tank (Blossom). PINAL COUNTY Casa Grande Ruins. YUMA COUNTY: Gila Valley, five miles east of Yuma; nineteen miles east of Wellton

Crotalus lepidus klauberi Gloyd. Green Rock Rattlesnake

We found this little-known rattlesnake at elevations above 6000 feet in the Huachuca and Chiricahua Mountains. It occurred in piles of rock along trails or among the great masses of loose stones of the numerous rock slides where the blue-gray or greenish gray color of the snakes harmonized most effectively with the color of their surroundings. Some were sunning themselves on the tops of flat rocks, others were beneath stones or pieces of bark, and two were in the open. All were very timid in behavior, invariably trying to escape and rarely showing much resentment even when pinioned. Sometimes a snake concealed near a trail made its presence known by rattling but the sound was of such slight amplitude that it was heard with difficulty.

Very little appears to be known of the food of this species. Some of our captive specimens ate mice, in some cases with marked eagerness. After striking a mouse in the usual way, one individual followed up its victim, seized it and held it firmly until all struggles ceased, then began swallowing it at once. It seems probable that lizards such as *Sceloporus jarrovii,* which are abundant in the rock slides inhabited

by the snakes, form a considerable part of the food of this species.

As nothing seems to have been published regarding the young of *Crotalus lepidus klauberi*, the inclusion of the following fragmentary notes may be justified. Several green rattlesnakes collected in the Huachuca Mountains early in July, 1928, were sent to me for study by Dr. E. H. Taylor of the University of Kansas. Among these was a gravid female which died in transit and arrived in a badly decomposed condition. It was about fifteen inches long and contained two embryos, one of which measured 160 mm. in length. The egg tooth, now probably to be regarded as a vestigial structure in ovoviviparous reptiles, was present in this individual but small and inconspicuous, scarcely projecting beyond the lower edge of the rostral plate.

Mr. L M. Klauber of San Diego, California, has permitted me to include here the measurements of a brood of six young in his collection. They were obtained by F. E. Walker and L. H. Cook, July 21, 1930, in Brown Cañon, Huachuca Mountains. All were found close together in a small area and there is little doubt that they were newly born. The measurements made by Mr. Cook follow:

Sex	Total Length, mm	Tail Length, mm
♂	207	16
♀	211	14
♀	211	14
♂	214	15
♀	216	12
♀	220	12

Localities. COCHISE COUNTY. Ash, Carr, Miller and Ramsey Cañons, Huachuca Mountains, Rhyalite Park, north end of Chiricahua Mountains.

Crotalus molossus molossus Baird and Girard. Black-tailed Rattlesnake.

In the Huachuca Mountains we obtained the black-tailed rattlesnake at elevations between 5200 and 8000 feet. One was taken in the western foothills of the Chiricahua Mountains at slightly more than 5000 feet. From our observations it was not possible to associate this species with any particular habitat. It occurred on rocky slopes with few loose stones, at the edges of rock slides, coiled in the middle of a trail, in the opening of an abandoned "prospect", on ledges below trails, and on a pile of boards in a shed.

There was little color variation in the series collected. With few exceptions the ground color of adults was brilliant yellow in strong contrast with the deep black rhombs which were conspicuously, though incompletely, bordered with white. In one, however, the rhombs were

FIG 19 Black-tailed Rattlesnake, *Crotalus molossus molossus*, in a trail in Ash Cañon, Huachuca Mountains

brown rather than black, and in a young specimen the ground color was more green than yellow, resembling the general color tone of Texas representatives of this species.

Different field observers appear to have gained varying impressions regarding the general disposition and behavior of *molossus*, some reporting it to be quick, nervous and aggressive and others indicating just the opposite. Only one of those secured by us showed a special tendency toward viciousness. This individual was moving rather rapidly across a mountain slope shortly after sundown and took the offensive as soon as it was disturbed. All others were in a more passive state when encountered. One found sunning itself in the middle of a trail (fig. 19) paid not the slightest attention while several photographs were made at a distance of three feet. When it was eventually disturbed it attempted to escape over the downward side of the trail. Another concealed from view by thick bushes fifteen feet below the level of a trail rattled vigorously as we passed but struggled little when captured.

No observations on the food habits of this species appear to have been published. Some that we sent to the laboratory would eat neither rats nor mice.

Localities COCHISE COUNTY Ash, Carr and Miller Cañons, Huachuca Mountains, western foothills of the Chiricahua Mountains near Bonita Cañon, twenty miles southeast of Dos Cabezas; Chiricahua National Monument (Painter) GILA COUNTY. three miles north of Roosevelt Dam (Sanders). PIMA COUNTY· San Diego Cañon, east side of Baboquivari Mountains (Painter). YAVAPAI COUNTY: in the cedar belt of Tusayan National Forest, eleven miles south of Ashfork.*

Crotalus scutulatus (Kennicott) Mojave Rattlesnake.

According to the known distribution of this species, it is a lowland form, characteristic of the plains and desert of the Lower Sonoran Zone. Its range in Arizona includes all of the area south and west of the central plateau. All of our specimens were taken below 4500 feet, in the valleys of the southern and western part of the state. Three were beneath low mesquite trees, two were crossing highways through mesquite country, one was dug out of a mammal burrow, one was found in a sandy arroyo and another in a thick growth of creosote bush.

Klauber (1930, p 54) states that in Arizona this species ascends to considerable altitudes in the vicinity of Prescott and that specimens from the higher areas are darker, "a deep brown or even black replacing the green of the lowland forms." That this darker coloration may not be restricted to individuals from higher elevations is indicated by a specimen from a mesquite flat of the upper Sulphur Springs Valley, in which the ground color, the centers of the dorsal blotches, and most of the sides are dark olivaceous brown, the usual green showing only in the lighter borders of the blotches and in small, irregular patches on the sides.

The coloration of a specimen found in the Lechuguilla Desert near Tinajas Altas (fig. 20), exhibits a high degree of flavescence. The ground color was bright greenish yellow, with yellowish olive dorsal blotches.

A small individual taken near Ajo, August 14, 1930, may be a young of the year. It measured 250 mm. in total length.

Localities. COCHISE COUNTY: Sulphur Springs Valley, seven miles northwest of Willcox; ten miles east of Willcox; twenty-three miles southwest of Dos Cabezas; seventeen miles southeast of Dos Cabezas; Bisbee (Bowman); San Pedro Valley, eight miles north of Tombstone*; four miles west of Hereford*. GRAHAM COUNTY: Gila Valley, forty-five miles northwest of Safford*. MARICOPA COUNTY: twelve miles east of Mesa; ten miles southeast of Mesa (Sanders). MOJAVE

*Dead on the road

FIG 20 An unusually flavescent specimen of the Mojave Rattlesnake *Crotalus scutulatus* taken in the Lechuguilla Desert near Tinajas Altas

COUNTY: nine miles east of Kingman. PIMA COUNTY: Well No. 1, six miles northeast of Ajo. YUMA COUNTY: Gila Valley, nineteen miles east of Wellton; Lechuguilla Desert, three miles east of Tinajas Altas.

Crotalus tigris Kennicott. Tiger Rattlesnake.

One specimen of the tiger rattlesnake was taken in the sahuaro-ocotillo association of the Cañada del Oro. It was found by Dr Smith about midafternoon of August 4, 1930, in the shade of a mesquite tree near a dry arroyo more than a mile and a half from the mountains. It was sent to the laboratory alive and kept for some time. Mice were offered as food but were not eaten.

Locality. PIMA COUNTY: Cañada del Oro, twenty miles north of Tucson.

Crotalus triseriatus pricei Van Denburgh. Arizona Spotted Rattlesnake.

Our diligent search for this species in the Huachuca Mountains was unrewarded but we secured four specimens in the Chiricahua range on August 21, 1931, at an elevation of 7200 feet. The locality (fig. 5) is a high ridge on the western slope near the headwaters of Turkey

Fig 21 Arizona Spotted Rattlesnake *Crotalus triseriatus pricei* Morse Canon Chiricahua Mountains elevation 7200 feet (See figure 5)

Creek in what is called Morse Cañon on the U S Geological Survey topographical map (Chiricahua Quad , ed of 1919) and Mormon Cañon of the U S Forest Service map of the Coronado National Forest (1927)

A small individual was coiled in a spot of sunlight on a ledge and another was startled from a bunch of grass Since the condition of the rattle indicated that they had undergone only the first ecdysis, they were judged to be young of the year One is 193 and the other 206 millimeters in total length

One of the two adults was coiled on a horizontal flat stone at the edge of a rock slide The other was near the crest of the ridge in a shallow crevice among a rich growth of ferns, mosses and lichens (fig 21)

Remarks of residents in the Chiricahua region indicate that this species is more abundant than ordinarily supposed Ranchers and members of the Forest Service stated that small rattlesnakes which they called ' mountain sidewinders" were commonly met with at higher elevations in many parts of the range

That this rattlesnake feeds upon *Sceloporus jarrovii*, a very common lizard in the same habitats, was shown by the presence of a large

quantity of scales of that species in the foeces of one of the larger snakes In captivity no food was taken although mice were offered

Locality COCHISE COUNTY Mormon (or Morse) Cañon between Turkey Creek Ranger Station and Chiricahua Peak, Chiricahua Mountains

TORTOISES

Terrapene ornata (Agassiz) Western Box Tortoise

Box tortoises were collected in dry arroyos and on the mesquite plains of the San Pedro and Sulphur Springs Valleys

Localities COCHISE COUNTY four miles east of Hereford, seven miles southwest of Tombstone, eight miles southeast of Dos Cabezas, one mile west of Dos Cabezas

Gopherus agassizi (Cooper) Desert Tortoise

A desert tortoise (fig 22), was taken about 5 00 P M in the sahuaro-ocotillo association of the Cañada del Oro, Pima County, twenty miles north of Tucson

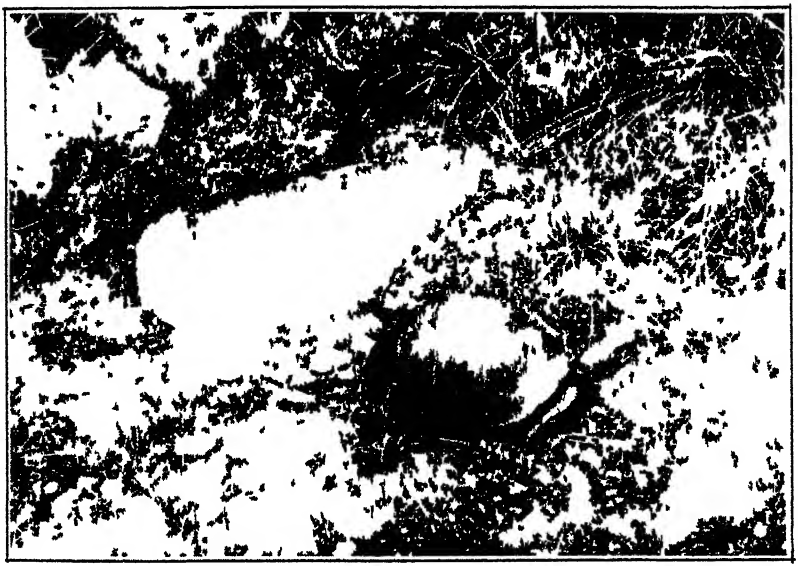

Fig 22 The Desert Tortoise *Gopherus agassizi* Cañada del Oro twenty miles north of Tucson

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BULLETIN

OF THE

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MAMMALS OF THE GREAT SMOKY MOUNTAINS

BY

EDWIN V. KOMAREK
Cooperative Quail Study Association
AND
ROY KOMAREK
North Carolina Department of Conservation and Development

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MAMMALS OF THE GREAT SMOKY MOUNTAINS

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The interest of the writers in the mammals of the Great Smoky Mountains is largely an outgrowth of a preliminary study made in that region in the spring of 1931 by a field party from the Chicago Academy of Sciences and the University of Chicago. Cursory collecting during this short visit revealed the presence of a new *Microtus* (Komarek, 1932) which led to further consideration of the area now comprising the Great Smoky Mountains National Park. In the spring of 1932 a detailed study of the mammals of this section of the southern Appalachians was undertaken and field work was continued at various times during the following two years in the interests of the Academy and with the cooperation of the U. S. National Park Service. Since the greater part of this investigation was carried on before the Park was developed this report establishes a basis for comparing the effects of the formation of the National Park upon the mammalian life of the region.

Preliminary field work was carried on from March 30 to April 25, 1931, by R. L. Boke, D. C. Lowrie, and Charles H. Seevers of the University of Chicago, Walter L. Necker and E. V. Komarek of the Academy. At this time activities were largely limited to the Greenbrier section of the Park and the vicinity of Smokemont, Swain County,

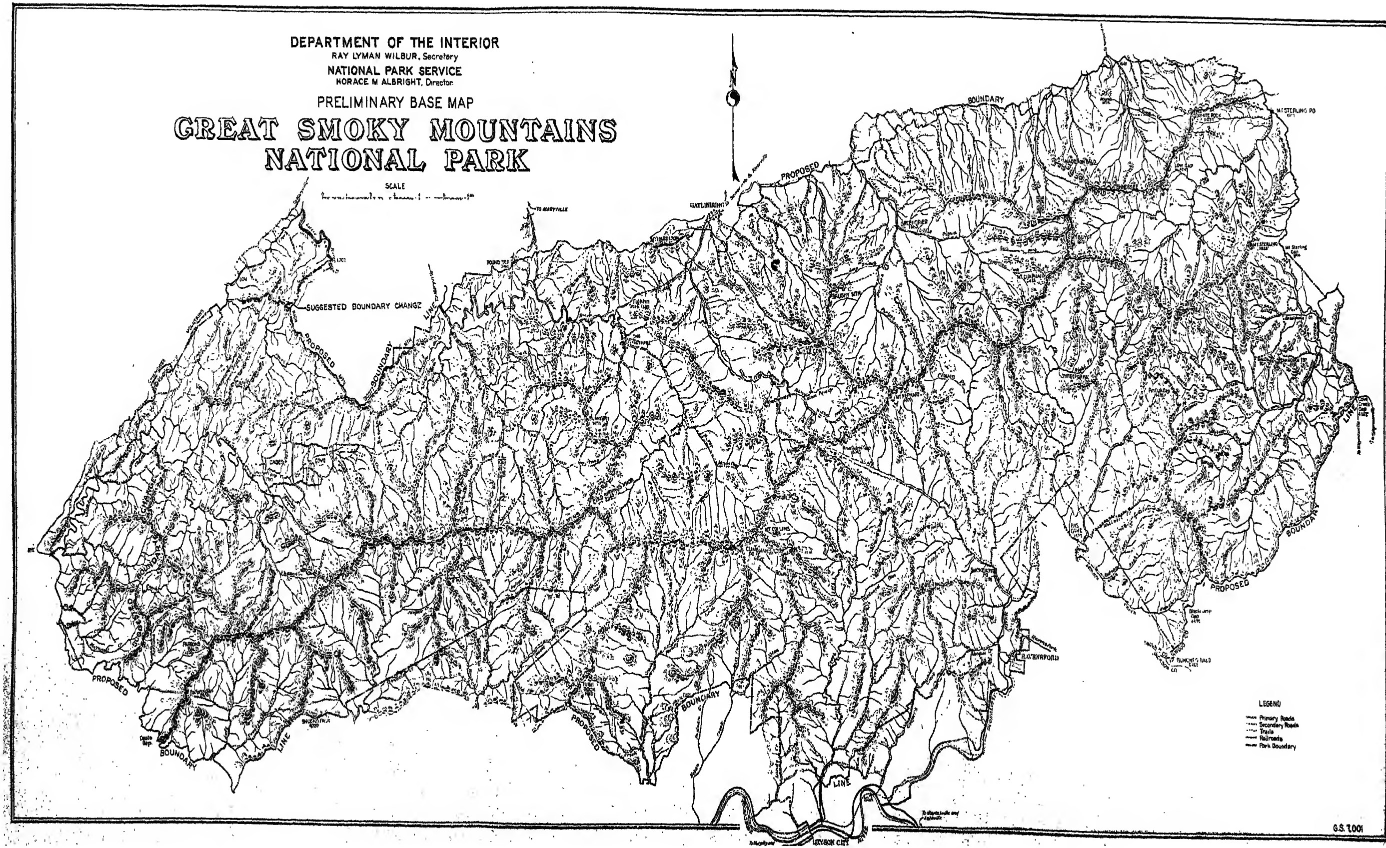
North Carolina. On February 15, 1932, headquarters were established at Greenbrier, Sevier County, Tennessee, and the study was continued by the writers, in various parts of the Park Area, through the following two years.

For cordial assistance and cooperation throughout the progress of this study we are grateful to Alfred M. Bailey, former Director, and Francis R. Dickinson, President of the Chicago Academy of Sciences; to Conrad L. Wirth and Dr. H. C. Bryant of the National Park Service; to Superintendent J. Ross Eakin, Assistant Chief Ranger Charles S. Dunn, and other members of the staff of the Great Smoky Mountains National Park; and to many residents of the Park Area, especially Fire Guards Ennis Ownby and William Ramsey, and Elbert Whaley, former trapper. We are also indebted to Arthur H. Howell and Dr. H. H. T. Jackson of the Bureau of Biological Survey and Dr. W. H. Osgood of the Field Museum of Natural History for the identification of certain specimens of mammals; to Dr. F. C. Bishopp of the Bureau of Entomology and Dr. E. W. Price of the Bureau of Animal Industry who have identified the parasites collected; and to Dr. W. C. Allee of the University of Chicago and Dr. H. K. Gloyd, Director of the Chicago Academy of Sciences, for helpful suggestions during the preparation of the manuscript. The map of the Great Smoky Mountain National Park is reproduced by courtesy of the National Park Service.

DESCRIPTION OF REGION

The Great Smoky Mountains National Park, some 428,000 acres, extends along the Tennessee-North Carolina boundary line for about sixty-five miles and includes within its area some of the finest virgin timber to be found in eastern United States. In this region the culmination of the Appalachian System is reached; it is characterized by rugged mountains, a rainfall approaching one hundred inches, luxuriant vegetation, and a rich fauna. Many of the peaks rise to a height of more than six thousand feet with summits approximately a mile above their bases but there is no definite timber line. The elevation of Clingman's Dome, the highest peak within the Park, is 6642 feet. The higher peaks are frequently enveloped in fog or low hanging clouds—a condition which contributes to the production of a humid environment and which, together with the ever-prevailing blue haze, accounts for the name given this range of mountains.

A large part of the Park Area was cut over many years ago and is now replaced by second growth of considerable size. Because of


DEPARTMENT OF THE INTERIOR
RAY LYMAN WILBUR, Secretary
NATIONAL PARK SERVICE
HORACE M ALBRIGHT, Director
PRELIMINARY BASE MAP
GREAT SMOKY MOUNTAINS
NATIONAL PARK
SCALE
N
GATLINBURG
TO MARYVILLE
SUGGESTED BOUNDARY CHANGE
PROPOSED
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BRYSON CITY
LEGEND
Primary Roads
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Trails
Railroads
Park Boundary
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their inaccessibility, two large areas, one about Mt. Guyot and the other known as the Morton Butler tract at Cades Cove, have remained primitive in character. Much of the land at lower elevations has been subjected to subsistence cultivation which favored, somewhat, the increase of certain forms of animal life. A large, well-cultivated valley, approximately four miles long by about two miles wide, known as Cades Cove, is located in the western end of the Park and is the only valley with a broad, comparatively level floor within its boundaries.

INFLUENCE OF MAN

The Great Smokies have frequently been considered one of the most primitive of existing wilderness areas east of the Mississippi and, though such an assertion is well founded, the region is far removed from a true virgin area biologically. Cultivation, lumbering, hunting and trapping have so changed the greater part of the Park that only bare vestiges of past conditions remain on the higher, more inaccessible peaks, and even these were frequented more or less regularly by the hardy mountaineer and his squirrel rifle long before hikers conceived the idea of the Appalachian Trail.

The mountains provided a source of food supply for the Indians and early explorers. These early inhabitants affected the mammalian life directly but their numbers were small and, compared to later immigrations, had little effect on the environment as a whole. The settlers followed and as their numbers grew, more land was cleared and more fields were created. This primitive cultivation induced favorable game conditions. In the early literature are many references to the abundant wild life of this period. Because of the increased productivity of the habitat and in spite of the increased kill for food, the populations of certain species again approached a state of equilibrium with the increase of human population. Lumbering operations later changed the character of large areas in a comparatively short time. Large sections of virgin forest were harvested, leaving cut-over lands that soon grew up to young timber and rough tangles of briers, bushes, and vines. The effect of these activities was the creation of new faunal environments and the consequent adjustments to them.

Before the Park was established, inaccessible as the region was, many sections supported a human population greater than at first might be suspected. Numerous cabins were strung out along eroded, rock strewn, almost impassable mountain roads reaching far in toward the North Carolina-Tennessee State Boundary. Most of these have now been removed in accordance with the National Park policy and

due to the character and climate of the country where vegetative growth is rapid, evidence of human habitation in many places is no longer apparent. At one time the little mountain community known as Big Greenbrier Cove (fig. 1), located in one of the wildest sections of the Park, is said to have had a voting population of over 200 people and some 250 children attended school near the forks of the Little Pigeon River. It appears as Brier in the Century Atlas. As late as the spring of 1931 more than fifty families resided in this settlement. In spite of this human population the game animals, with the exception of deer, have persisted in numbers large enough to respond favorably to protection.

Indiscriminate burning of the wooded slopes each spring or fall was widespread and in lands adjacent to the Park it still is. Under certain atmospheric conditions severe, wind-driven fires unquestionably destroyed food, cover, and breeding sites of animals thus rendering the environment temporarily unproductive. In some instances through this agency, however, and through inefficient farming and grazing, the distribution of certain species of animals may have been extended. This is indicated by the presence of the lemming vole, *Synaptomys cooperi stonei,* taken in grassy openings at an elevation of 2900 feet along Little River. At this locality timber had been cut out and fire, farming, and grazing had retarded the process of reversion to forest, temporarily maintaining the plant succession at the bush-sapling level with open grassy patches, a habitat compatible with the environmental needs of this particular rodent.

HABITATS OF MAMMALS

Although a detailed study of the habitats of the Park Area was not attempted, the following brief discussion is included to give a general picture of the various habitat types.

Beech-maple Habitat. The climax forest association consists of beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and hemlock (*Tsuga canadensis*) and occupies extensive areas between elevations of about 3000 and 4000 feet. It is a humid habitat with large, dense stands of timber in which the yellow poplar reaches a diameter of six feet and over. There is much forest litter and rotted, damp, moss-covered logs are present in great numbers. An understory is made up of small saplings of the above mentioned trees with thickets of rhododendron distributed throughout in suitable moist places.

Beech Habitat. In a few areas beech occurs in solid though somewhat open stands with comparatively little underbrush. A stand of

considerable size with trees dwarfed and gnarled by wind is located along the divide near Siler's Bald.

Spruce-fir Habitat. This habitat is composed of virgin spruce (*Picea rubens*) and Frazer's fir (*Abies frazeri*) both of which reach a diameter of three to four feet and often occur as a dense, solid forest. It is found on many of the higher peaks, is subjected to frequent local rains and much of the time is enveloped in fog or low hanging clouds. A rocky substratum with little earth and humus supports a luxuriant, thick mat of moss which makes up the forest floor and which is exceedingly moist the year round.

Oak-chestnut Habitat. The oak-chestnut habitat is located at lower elevations and is composed largely of second growth black oak (*Quercus velutina*) and chestnut (*Castanea dentata*). There is an abundance of dead chestnut trees—their gray, bark-stripped bolls standing conspicuously among the oaks and maples of the lower ridges —bearing evidence of the effect of the chestnut blight in this area. A few stands are still holding their own on some of the higher ridges and other restricted areas. A tree measuring nine feet in diameter is located about three miles above Greenbrier in what is known as Porter's Flats. The passing of this extremely important food species no doubt affected many of the mammals of this region but mast in abundance is still supplied by the oaks, maples, and silver bells. Chestnut mast was fairly heavy during the fall of 1933 on the summits of Mt. Harrison and the Pinnacle.

Heath Bald Habitat (fig. 2). The heath bald habitat is apparently the least favorable to mammals. Such balds are locally known as "slicks" and are composed of a thick growth of mountain laurel (*Kalmia latifolia*) and greenbriar (*Smilax* sp.). Many of them are of considerable size extending for some distance along the tops and slopes of ridges varying in height from three to five thousand feet. The summits of Brushy Mountain and the Bullhead are prominent examples of this habitat. In late spring and early summer the "slicks" are a mass of laurel blossoms presenting one of the picturesque settings for which the Smokies are noted. The cloudland deermouse (*Peromyscus maniculatus nubiterrae*) was the only mammal collected in extensive areas of solid laurel. Tracks and feces of wildcats were noted in trails cutting through the "slicks".

Grassy Bald Habitat (fig. 3). The treeless, grass covered mountain tops located in the western end of the park are locally known as "balds" and, though of considerable extent, are inhabited only by mammals characteristic of higher timbered altitudes. Where shrubs occurred

in isolated clumps surrounded by grass the cloudland deermouse (*P. m. nubiterrae*) and the red-backed mouse (*Clethrionomys gapperi carolinensis*) were taken, while in the crevices of rock outcrops on Thunderhead traps yielded the Smoky Mountain rock vole (*Microtus chrotorrhinus carolinensis*).

Rhododendron Habitat (fig. 4). Although thickets of rhododendron (*Rhododendron maximum* and *catawbiense*) are commonly found along streams, they often cover large areas at high altitudes along the tops of ridges where they grow to considerable size and luxuriance making travel very difficult. It is in such "roughs" that bear trails frequently aid the hiker.

Broomsedge Field Habitat. When cultivation is discontinued fields soon grow to a thick cover of broomsedge (*Andropogon* sp.) and form a habitat which supports a rich mammalian fauna, both in numbers and species. The exodus of people from the area resulting from land purchases for the creation of a National Park, left many fields untended and greatly increased the extent of this habitat (fig. 3). Within the Park, however, it is more or less temporary as reforestation is comparatively rapid and replacement of sedge fields by thickets of black locust (*Robinia pseudo-acacia*), sassafrass (*Sassafrass sassafrass*), and yellow poplar (*Liriodendron tulipifera*) is said to take place in about five years.

Fallow fields in various stages of reversion contained the same mammals. The results of trapping showed that mammals occurred in heavy, solid fields of broomsedge less frequently than in fields dotted with briar patches, rock piles, and openings created by grazing cattle. Rabbits, which were very abundant in open situations, were noticeably fewer in number in dense broomsedge. In preparing the soil for cultivation, rocks were thrown up into piles or rock fences, which furnished excellent protection from predators and were extensively utilized as retreats by these animals. During the winter months, red squirrels were also found living in rock piles located near black walnut trees (*Juglans nigra*). Wild grapes (*Vitis* sp.) grow abundantly along fence rows and in the fall of the year provide a food item of considerable importance to opossums and raccoons.

DISTRIBUTION OF MAMMALS

On the basis of their present distribution in this region and their affinities to species in other sections of North America, the mammals of the Great Smoky Mountains may be divided into three distinct series: (1) those with northern affinities; (2) those with southern

affinities; and (3) those of widespread distribution. In this classification we have included only those species of which we have sufficient knowledge to justify their allocation. The distribution of a species is in a more or less constant state of flux and is subjected to, and profoundly affected by, changes in environment. In the lower elevations where cultivated areas are more common, the instability of the distribution of mammals associated with such situations as recorded in this report should be emphasized. The region is unusually favorable to reforestation and the transition from field to forest is comparatively rapid. Consequently, field-inhabiting forms will eventually be eliminated from the Park Area in many sections.

Now that farming in the Park has been greatly restricted, an excellent opportunity exists for a study of the succession of the abandoned fields to determine the effect of the reversion from field to forest upon the population and distribution of certain mammals as well as wildlife in general. Such information is limited and data of this nature accumulated over a period of years would be of inestimable value in the management of this region.

Mammals with Northern Affinities. This element in the mammalian fauna may also be called the mountain-top fauna for it is composed of species found on the mountains from approximately 3000 feet elevation to the tops of the highest peaks. These mammals are generally races of northern species whose range of greatest abundance and development lies to the north of this region.

Clethrionomys gapperi carolinensis, Carolina Red-backed Mouse.
Microtus chrotorrhinus carolinensis, Smoky Mountain Rock Vole.
Napaeozapus insignis roanensis, Roan Mountain Jumping Mouse.
Peromyscus maniculatus nubiterrae, Cloudland Deermouse.
Sorex fumeus fumeus, Smoky Shrew.
Sorex cinereus cinereus, Masked Shrew.
Sciurus hudsonicus abeiticola, Appalachian Red Squirrel.

Mammals with Southern Affinities. This faunal element corresponds to what may be called the lowland community, as the species of which it consists are found from the outlying valleys up to approximately 2700 feet in the mountains. It has affinities with southern mammalian species for most of these mammals are found generally distributed through the southern states.

Cryptotis parva parva, Little Short-tailed Shrew.
Reithrodontomys humilis merriami, Harvest Mouse.
Peromyscus nuttalli nuttalli, Golden Mouse.
Peromyscus leucopus (intermediate between *leucopus* and *noveboracensis*), Woodland Deermouse.

Sigmodon hispidus hispidus, Cotton Rat.
Oryzomys palustris palustris, Rice Rat.
Pitymys pinetorum scalopsoides, Mole Pine Mouse.

This community is changing rapidly for most of the above listed mammals live in the cut-over lands and sedge-grass fields which are rapidly being reforested. It seems probable that many of these species have entered the mountain region after occupation by man. As these habitats are growing up into forest the mammals are being driven downward and outward. Some species such as the cotton mouse, the cotton rat, the rice rat and the little short-tailed shrew, which are found most commonly in the sedge fields, are becoming less abundant at higher elevations as these fields are turning into stands of young timber. Cotton rats were collected in 1931 and 1932 at Greenbrier at an elevation of about 1700 feet but since then have not been found that far back in the mountains. At that time they were found in two grassy areas. One of these is now reforested with young poplars and the other is a pasture closely cropped by cattle. Like the rice rat, of which only one specimen was taken, they were pioneer members of their species. They have probably been driven outward with the change in environment now that once cleared areas are in the process of reforestation.

Mammals of Widespread Distribution. The mammals which make up this series are species found from the lowest valleys in the Park, as well as those outside of the mountains, to the top of the highest peaks and are also found distributed over the eastern part of the United States both north and south of the Smoky Mountain range.

Blarina brevicauda talpoides, Large Short-tailed Shrew.
Marmota monax monax, Eastern Marmot.
Tamias striatus striatus, Eastern Chipmunk.
Procyon lotor, Eastern Raccoon.
Vulpes fulva, Eastern Red Fox.
Euarctos americanus, Eastern Black Bear.
Lynx rufus rufus, Eastern Bobcat.
Sylvilagus floridanus mallurus, Eastern Cottontail.
Synaptomys cooperi stonei, Stone's Lemming Vole.

ANNOTATED LIST OF SPECIES*

Didelphis virginiana virginiana Kerr. Virginia Opossum.

Ten specimens from Greenbrier, one from Three Forks.

The Virginia opossum, the most abundant fur-bearer, ranges throughout the greater part of the mountains though in diminishing numbers at higher elevations. It was found in and around old fields and in open woods along streams and often became a nuisance in trapping the larger mammals. According to local residents it was also very common in the past. Feces showed that a large part of the diet of the opossum in late summer and fall consists of blackberries (*Rubus allegheniensis*), poke berries (*Phytolacca decandra*), wild grapes (*Vitis* sp.) and persimmons (*Diospyros virginiana*). That their carrion-eating habit was quite pronounced was indicated by the increased effectiveness of traps after the bait became decomposed. One was taken in a trap baited with fish.

Breeding habits. A female collected on March 18 had 13 naked young about 24 mm. long in her pouch. Another taken on February 23 contained 8 embryos.

Parasites. Opossums were found infested with larval ticks (*Ixodes* sp.) and white round worms (*Physaloptera turgida*) were taken from the stomachs of the majority of specimens examined.

Measurements. Three males: total length (738-832) 781.6, tail (300-320) 311.6, hind foot (60-74) 69; five females: total length (671-725) 701.6, tail (285-310) 298.6, hind foot (59-66) 62.

Parascalops breweri (Bachman). Hairy-tailed Mole.

One adult female was taken along Chapman Prong (3200 ft.). It was trapped under a damp, mossy rock in a rhododendron thicket along a small stream. An immature female was collected on Buck Fork in a similar situation. Tunnels of this species were seen in soft soil covered with hemlock needles on the divide near Mt. Kephart (5200 ft.). These appear to be the first recorded specimens from Tennessee.

Measurements. One adult female: total length 151, tail 33, hind foot 18.

Scalopus aquaticus aquaticus (Linnaeus). Eastern Mole.

One specimen from Dry Valley, Blount County, Tennessee, just outside the Park boundary. Tunnels of this species were seen in the lower coves below 1500 feet elevation around fields where the soil was somewhat sandy.

* All measurements and weights are given in millimeters and grams respectively, extremes enclosed in parenthesis followed by averages.

Sorex longirostris longirostris Bachman. Bachman Shrew.

The humid nature of the Great Smokies and records of specimens collected in southwestern North Carolina and northern Georgia suggested the probable occurrence of the rare Bachman shrew in the Park Area but individuals of this species were not secured. We are therefore grateful to Mr. Willis King, Assistant Wildlife Technician of the Park for permission to include the following records:

"The present record is from Greenbrier, Tennessee, in Great Smoky Mountains National Park. Mr. Raymond J. Fleetwood, formerly Resident Wildlife Technician, found a male shrew of the species dead in a posthole, June 5, 1934. The posthole was in a field bearing a stand of sedge grass (*Andropogon*) at approximately 1600 feet elevation. The specimen was sent to the U. S. National Museum for identification and was added to the collection as USNM No. 258854.

"This species of shrew was found again February 4, 1936, in the same vicinity in one of the buildings of a CCC Camp. Dr. M. S. Crowder caught one in a mouse trap baited with cheese. The specimen was identified as *Sorex longirostris longirostris* by Mr. Arthur Stupka, Park Naturalist, and is now in the Park's study collection of vertebrate animals at Great Smoky Mountains National Park, Gatlinburg, Tennessee.

"The records of Bachman shrew in eastern Tennessee establish this species as occurring more than 100 miles north, and west, of the nearest record stations for the costal states and extends its known range in the southeast towards that in Illinois and southern Indiana."

Sorex cinereus cinereus Kerr. Masked Shrew.

Ten specimens: Smokemont, Clingman's Dome, Mt. Kephart, Buck Fork, Mt. Collins, Dry Sluice, Mt. Guyot.

This shrew was taken in the same habitat with the smoky shrew.

Measurements. Four males: total length (89-114) 101.7, tail (40-47) 43.2, hind foot (7-13) 11.2; five females: total length (98-110) 101.6, tail (45-50) 47.4, hind foot (8-13) 11.2. Weights of two females 4.05 and 4.27 grams.

Sorex fumeus fumeus Miller. Smoky Shrew.

Twenty-five specimens: Eagle Rock Creek, Clingman's Dome, Mt. Kephart, Chapman Prong, Dry Sluice, Little River (alt. 2900).

The smoky shrew was taken around or under damp, moss-covered rocks and fallen, rotted logs in both deciduous and evergreen forest, at elevations ranging from 2900 feet to the top of the highest peaks (fig. 6). Specimens collected in February, March, April and October were in the gray winter pelage.

Breeding Habits. A large female taken on October 12 at an altitude of 6200 feet was nursing. Two males taken on August 5 and 25 had greatly enlarged testes.

Measurements. Nine males: total length (113-125) 119.6, tail (42-50) 46.6, hind foot (12-15) 13.6; eleven females: total length (108-129) 116.9, tail (38-66) 49.7, hind foot (11-15) 13.9. *Weights.* Four specimens (5.50-10.55) 7.77. The female weighing 10.55 grams was nursing.

Cryptotis parva (Say). Little Short-tailed Shrew.

Thirty specimens: Greenbrier, Fighting Creek near Gatlinburg, Fish Camp Prong.

This little shrew was found in fallow fields at lower elevations. Specimens collected near Gatlinburg and at Greenbrier (Laurel Creek) were found in moderately over-grown broomsedge fields. Several individuals were trapped at the bases of pines and small apple trees. At Fish Camp Prong they were taken in the runways of Stone's lemming voles (*Synaptomys cooperi stonei*) which were located in an open grassy patch along the forest margin at an elevation of 2730 feet. This is the highest elevation at which this species was recorded. Shrews were frequently taken in traps baited with the bodies of mice. They were active day and night.

Breeding Habits. A female taken near Gatlinburg on October 16 was found to be through nursing. Four males collected on October 20 had enlarged testes.

Measurements. Ten males: total length (69-76) 74.3, tail (16-21) 18.4, hind foot (10-11) 10.2; six females: total length (70-84) 74, tail (15-20) 18, hind foot (10-10) 10. *Weights.* Six males: (3.28-5.48) 4.13 grams; eight females: (3.50-5.72) 4.45 grams.

Blarina brevicauda talpoides (Gapper). Eastern Short-tailed Shrew.

Sixty-nine specimens: Smokemont, Greenbrier, Mt. Kephart, Walker Prong, Horseshoe Mountain, Grassy Patch, Siler's Bald, Clingman's Dome, Fish Camp Prong.

The eastern short-tailed shrew was very abundant and was probably the most widely distributed mammal in this region occupying all types of habitat at all elevations. Its distribution is apparently unaffected by elevation for specimens were taken in the lowlands adjacent to the Park as well as on the higher peaks. The stomachs of two specimens contained the remains of a lepidopterous larva and a slug respectively. Occasionally these shrews were found dead in the trails but upon examination no indication of injury was noted. In one specimen a small spiral worm was found between the skin and flesh of the

shoulder.

Measurements Ten males. total length (105-116) 112.6, tail (21-28) 25, hind foot (12-16) 14.9; Ten females: total length (105-129) 115.2, tail (21-31) 26.4, hind foot (13-16) 15. *Weights.* Five males: (13.61-18.0) 16.13 grams; five females: (15.32-20.5) 17.93 grams.

Myotis lucifugus lucifugus (LeConte). Little Brown Bat.

Two specimens were brought to us by a mountain boy who caught them in a cabin in Greenbrier.

Lasionycteris noctivagans (LeConte). Silver-haired Bat.

Three specimens. Two were shot at dusk in Cades Cove on April 21. The other was found injured at Greenbrier on March 18.

Measurements. Two males: total length (92-98) 95, tail (35-42) 38.5, hind foot (11-11) 11; one female: total length 97, tail 39, hind foot 11.

Pipistrellus subflavus subflavus (F. Cuvier). Georgian Bat.

One specimen was collected by Ennis Ownby in the loft of a grist mill in Greenbrier.

Eptesicus fuscus fuscus (Beauvois). Big Brown Bat.

One was taken in the loft of a grist mill, November 1, 1932.

Lasiurus borealis borealis (Müller). Northern Red Bat.

Five specimens were shot at dusk at Cades Cove and Greenbrier.

Corynorhinus macrotis (LeConte). LeConte Lump-nosed Bat.

One was taken in the attic of an abandoned schoolhouse near Gatlinburg. Another was found clinging to the chimney above the hearth in our cabin in Greenbrier.

Measurements. Two males: total length (96-101) 98.5, tail 44, hind foot 10. *Weights.* One male, 7.15 grams.

Euarctos americanus americanus (Pallas). American Black Bear.

One female and a large male taken above Greenbrier and a male taken along Ramsey Prong. Black bears are common in the Park Area and appear to be on the increase. While individuals are infrequently seen, evidence of their activity in many areas is quite conspicuous.

The survival in the Park of a sizeable stock of bear, sufficient to yield a favorable increase with protection, may be attributed in large measure to the existence of more or less extensive rugged sections at higher elevations. These areas provide the necessary cover for protec-

tion and rearing of young, an important factor if a species is to persist. Trapping and hunting for consumption, sport or pelts were pursued by local people and to a certain extent by residents of nearby settlements and towns. That this periodical cropping merely equaled or remained slightly below the annual increment of the restricted range is attested by the occurrence of these animals in considerable numbers when the Park was first established.

It is sometimes desired to venture comparisons of past with present numbers to indicate the trend of the population, but when such comparisons are based on the frequency of occurrence of feces, fresh tracks, etc., the following point should receive attention in the case of bear in the Park. The bear in this region were restricted to the rugged regions by hunting, trapping, molestation by unrestrained hounds and possibly the mere presence of small scattered cultivated fields with attendant people. At the present time almost all of these factors have been removed and the bears are ranging more widely, increasing their field of activity to the lower more accessible areas. Consequently, bear sign is more frequently encountered. The recently built horse and foot trails throughout the Park now permit easy access to the heavy timbered and rough areas thus also increasing the possibility of seeing bear sign. While there is perhaps no doubt that these animals have increased (1934) since they first received Park protection the added numbers probably have not been as great as the more common occurrence of sign might indicate.

The food of the black bear in this region is variable and changes with the seasons. In spring after they leave their dens they feed on the tender leaves of plants and deciduous mast which has laid through the winter. In summer blackberries form part of their diet while in autumn examination of feces indicated they were feeding on acorns, chestnuts, wild grapes, persimmons, poke berries, and apples. The stomach of one of the specimens secured was distended with the remains of acorns. Throughout the year when opportunity exists, bears dig out and eat ground-hogs and other mammals which they are able to capture. Local hunters report that they eat carrion. A favorite bait with bear hunters of the region is the "barbecued" carcass of a ground-hog.

Procyon lotor varias Nelson and Goldman. Raccoon.

Five specimens from Greenbrier. Raccoons were found throughout the mountains at all elevations but they are probably more common along the streams at lower altitudes. In their search for aquatic food in spring, they frequently turn over small rocks in shallow streams. Evidence of this activity is especially noticeable and easily detected where moss covered rocks have been disarranged exposing the bare

under-surfaces in marked contrast to the surroundings. During the fall of 1932 a number of raccoons made nightly raids on a wild grape thicket along the right fork of the Little Pigeon River in Greenbrier. Several were reported seen during the day. The specimens secured were parasitized by ticks (*Ixodes* sp.) and fleas. From an examination of stomachs and feces, their food consisted of wild grapes, pokeberries, and salamanders and other aquatic animals.

Measurements. One male: total length 784, tail 244, hind foot 107.

Mustela noveboracensis notia (Bangs.) Southern Weasel.

Four specimens from Lower Ramsey Branch and Pinnacle; one from Knoxville, Tennessee. Weasels are generally distributed throughout the mountains at all elevations though probably not so common in the dense evergreen forests. These are provisionally included under this subspecies but are probably intermediate with the northern race.

Measurements. Three males: total length (373-383) 377, tail (110-126) 118, hind foot (40-47) 44.3.

Mustela vison mink (Peale and Beauvois). Common Mink.

No specimens secured. A mink was caught in Greenbrier by Elbert Whaley and kept for us but had decomposed and had been thrown away before we arrived. Another was seen by Mr. Ownby and E. V. Komarek in the spring of 1933. Information secured from Mr. Whaley suggests that the mink apparently frequents lower, more open situations in winter and retreats into the deeper forest to rear its young in spring and summer.

Spilogale putorius (Linnaeus). Alleghenian Spotted Skunk.

A single individual was taken along a stream in cut-over woods. This species is said to be less common than the Florida skunk.

Mephitis elongata (Bangs). Florida Skunk.

Five specimens from Greenbrier and the Pinnacle. This skunk is generally distributed throughout the mountains but is probably more common about open fields and cut-over woodlands at lower elevations. Individuals of this species were heavily infested with ticks (*Ixodes* sp.), lice (*Neotrichodectes*) and tapeworms (*Oochoristica* sp., probably *mephitis*).

Measurements. Three males: total length (579-634) 598.6, tail (203-237) 215, hind foot (64-69) 66.5.

Vulpes fulva (Desmarest). Eastern Red Fox.

A red fox was found dead by Ennis Ownby along Dudley Creek where it probably fell exhausted after being run by hounds. Another

was seen in the early morning at Hall's Gap in North Carolina not far from Spence Field.

In 1932 we were informed that a number of foxes had been liberated in areas adjacent to the Park but the desired details could not be obtained. In answer to a request for information on this matter, Willis King, Assistant Wildlife Technician, National Park Service, kindly investigated further and secured the following notes from the Blount County, Tennessee, Fox Hunters Association. In a communication of October 5, 1936, Mr. King writes: "Mr. W. T. Griffiths and Homer Willicks, officials in the Association, advised me that about 150 red foxes were liberated in Chilhowee Mountain from near Sevierville to the Tennessee River, during the years from 1924 to 1926. Points of liberation mentioned were Callahan, Montvale, Townsend, Walland, Allegheny and Chilhowee. The animals were shipped from Waterloo, Minnesota. According to their description, the animals are distinguishable from the native red fox in that they appear somewhat larger, are more yellowish and have more white on the face and tip of the tail. The legs were described as being less dark than those of the native animals. From this description it would appear that the introduced form may be the species *Vulpes regalis*".

Urocyon cinereoargenteus cinereoargenteus (Schreber). Eastern Gray Fox.

No specimens taken. It is said to be less common than the Red Fox.

Lynx rufus rufus (Schreber). Wildcat.

Three specimens from Greenbrier.

The wildcat is generally distributed throughout the mountains at all elevations. Feces and tracks were frequently seen near Mt. Guyot, Brushy Mountain and along the Appalachian Trail from Newfound Gap to Clingman's Dome. On several occasions fresh tracks were noted in the road in front of the hotel in Greenbrier. Feces deposited in piles at intervals, a characteristic habit of the wildcat, were found along the crest of the Pinnacle. Judging from the size and state of disintegration of the remains in these accumulations. the top of this mountain had been the regular haunt of several cats. Specimens were heavily infested with fleas.

Measurements. One female: total length 760, tail 145, hind foot 152.

Marmota monax monax (Linnaeus). Southern Woodchuck.

Four specimens, three from Greenbrier, one from Three Forks. The ground-hog or "whistle-pig" of the mountaineer is common in many of the rocky slopes in deciduous forests as well as in fields and

cut-over lands throughout the mountains. The marmot occasionally does considerable damage to small cornfields. One field visited in July, 1932, was badly damaged and about two acres of corn were literally mowed down. The stalks were cut off about twelve inches from their bases, thus dropping the ears of corn to the ground where they were eaten. A half grown individual taken in August, 1932, was feeding on clover.

Measurements. Two females: total length (614-630) 622, tail (92-148) 120, hind foot (90-98) 94.

Tamias striatus striatus (Linnaeus). Eastern Chipmunk.

Twenty-one specimens from Greenbrier, Eagle Rocks Creek, Porter's Flats, Mt. Harrison, Horseshoe Mountain, and Thunderhead.

The eastern chipmunk is common throughout the mountains, especially in open deciduous woods. They are found at all elevations though less abundant in the dense evergreen forests on such peaks as Mt. Guyot. They were frequently seen feeding on acorns (*Quercus* sp.), chestnuts (*Castanea dentata*), the mast of silver bell (*Halesia carolina*), beech (*Fagus* sp.), and other trees. Where such food is abundant they apparently form colonies. Since these squirrels were observed in every month of the year they apparently do not hibernate for any great length of time. They were not seen during cold periods but made their appearance if the weather became warm for a few days.

Measurements. Thirteen males: total length (238-278) 233.3, tail (70-92) 81, hind foot (30-40) 33.3; five females: total length (208-244) 225.2, tail (72-85) 80.4, hind foot (33-36) 34.6. *Weights.* Three males: (78-105.5) 98.6 grams; one female 79.5 grams.

Sciurus hudsonicus abieticola Howell. Alleghenian Red Squirrel.

Forty-five specimens: Greenbrier, Horseshoe Mountain, Buck Fork, Newfound Gap, Ramsey Prong, Mt. Collins, Smokemont, Porter's Flats, Dry Sluice, Mt. Kephart, and Mt. Guyot.

Red squirrels are commonly known in this region as "boomers". During the summer months their shrill chatter is a characteristic note in the woods at higher elevations. They were found very abundantly and range throughout the mountains in both deciduous and evergreen forests. While they probably spend the greater part of the year at more elevated regions, in winter they are frequently seen in the lower settlements feeding on black walnuts in the course of which their faces become stained with the dark juices in the hulls of these nuts. In the winter also they were seen feeding on acorns, chestnuts, beechnuts, and the mast of silver bell, maple and buckeye trees, the buds of which

form a considerable part of their diet in the spring. During the summer they were often observed at higher altitudes eating blackberries and spruce cones.

In 1932 red squirrels were not seen about our cabin in the settlement of Greenbrier until in the fall when two were found raiding our supply of walnuts stored under the porch. They stayed with us for several months but disappeared in the spring although an abundance of walnuts remained. A half grown specimen was taken on October 9. Assistant Chief Ranger Dunn reported seeing two melanistic red squirrels at Cosby in 1934. Fleas, mites and lice were taken on these squirrels.

Measurements. Seventeen males: total length (293-340) 312.4, tail (117-150) 133, hind foot (43-51) 47.8; fifteen females: total length (295-329) 322.5, tail (116-169) 130.8, hind foot (46-50) 48.

Sciurus carolinensis carolinensis Gmelin. Southern Gray Squirrel.

Sixteen specimens: Russell Field, Greenbrier, Horseshoe Mountain, Fighting Creek, and Ramsey Prong.

Southern gray squirrels were more common at lower elevations though at high altitudes they were frequently seen in the hardwoods along the divide at Russell Field. Unlike red squirrels, they were seldom if ever found in the coniferous forest. They were associated almost exclusively with deciduous woods and field margins where during the autumn and winter they fed upon acorns, chestnuts, beechnuts, and the mast of buckeye and silver bell trees. In the spring they were observed feeding on the buds of a variety of bushes and hardwood trees. This species was not as common as the preceding. However, where the mast was heavy it occasionally was found in considerable numbers.

Local residents frequently referred to the incompatibility of the "boomer" and gray squirrel and on one occasion the reactions of these two species upon meeting was observed. While collecting on a wooded slope near Greenbrier one winter morning we saw a gray squirrel run into a hole about twenty feet from the ground in a silver bell tree which was still heavy with mast. Shortly afterward a red squirrel, without apparent knowledge of the presence of the gray, made its way up the same tree. When it reached the hole it hesitated. Immediately the gray squirrel jumped out and dashed down the tree with the chattering "boomer" in close pursuit. The chase continued for several hundred feet.

A nursing female was taken on March 11. Two males with enlarged testes and two half-grown individuals were collected in October. Specimens taken throughout the year were heavily infested with fleas.

Measurements. Six males: total length (441-463) 453, tail (200-

250) 213, hind foot (65-69) 67; five females: total length (428-477) 452, tail (185-234) 213.8, hind foot (62-68) 65.

Sciurus niger subsp. Fox Squirrel.

Information from reliable sources indicates that fox squirrels are common in certain localities adjacent to the Park. Although no specimens were secured within the Park Area, residents assert that these squirrels were locally common in the area some years ago. Under protection they may be expected to drift in again.

Glaucomys volans saturatus Howell. Southeastern Flying Squirrel.

Five specimens: Greenbrier, Smokemont, Knoxville.

Three specimens from Knoxville were taken in bird boxes by H. P. Ijams in deciduous woods surrounding a small artificial lake or pond. The other two specimens were taken in a mixed forest in the Park Area at elevations of 2500 and 3000 feet respectively.

Measurements. Average for two females: total length (232-250) 241, tail (93-109) 101, hind foot (31-31) 31. One male: total length 228, tail 103, hind foot 31. *Weights.* One male 65 grams; one female 97.59 grams.

Reithrodontomys humulis merriami (Allen). Merriam Harvest Mouse.

The harvest mouse was found locally distributed in a few isolated places. Seven specimens from Sevier County were secured, six of which were taken in small cleared areas under apple trees in a moderately overgrown broomsedge field. The seventh was trapped at the entrance to a small hole under a rock in a similar field along Laurel Branch in Greenbrier. Little short-tailed shrews were taken in the same vicinity. The highest elevation at which specimens were obtained was 1500 feet. A female taken on October 18 had enlarged mammary glands. One stomach examined contained unidentified seeds.

Measurements. Three males: total length (113-122) 116, tail (52-57) 54, hind foot (14-15) 14.6; three females: total length (113-134) 120, tail (50-64) 55, hind foot (14-15) 14.6. *Weights.* One female: 12.4 grams.

Peromyscus maniculatus nubiterrae (Rhoads). Cloudland White-footed Mouse.

More than one hundred specimens: Greenbrier, Chapman Prong, Brushy Mountain, Buck Fork, Eagle Rocks Creek, Grassy Patch, Thunderhead, Walker Prong, Mt. Guyot, Siler's Bald, Russell Field, Clingman's Dome, Ramsey Prong, Mt. Kephart, Mt. Collins.

This species inhabits the colder more humid situations at high altitudes (fig. 6). It was the most abundant mammal taken along the divide where it occupies the spruce-fir forest as well as the more or less open woods and margins of the grassy balds. At lower elevations where deep, shaded ravines, and heavy forested areas with dense crowns which tend to produce a cooler environment, are found, these mice range as low as 2500 feet.

Two females taken on March 31 contained three and four embryos respectively. The embryos of the latter were ten millimeters in length. Another collected on February 21 had four well developed embryos and two taken on August 24 had three and four embryos respectively.

Tapeworm cysts of a species not determined, and nematodes (*Longistriata and Oxyuris* sp.) were found in the intestines and cecae of some of the specimens collected.

Measurements. Ten males: total length (161-206) 181.6, tail (86-114) 95.6, hind foot (19-22) 20.6; ten females: total length (163-203) 184.2, tail (80-111) 94, hind foot (19-22) 20.8. *Weights.* Fifteen males: (15-65—21.8) 17.8 grams; nine females: (15.8—21.15) 20.03 grams.

Peromyscus leucopus leucopus (Rafinesque). Southern White-footed Mouse.

Thirteen specimens; Greenbrier, Porter's Flats, Fish Camp Prong.

Mammalogists who have had occasion to work with *Peromyscus* have no doubt been confronted with the perplexing problem of assigning names to individuals from areas of intergradation. Such is the situation in the Smoky Mountain region where the range of *Peromyscus leucopus noveboracensis* blends into the northward distribution of the typical and more southern subspecies *Peromycus leucopus leucopus.* A comparative study of specimens from northern and southern localities would be necessary to determine definitely the relationships of specimens from this area. However, certain characters seem to indicate a closer affinity to the typical form and our specimens accordingly are listed here as *Peromyscus leucopus leucopus.*

This species inhabits the open woodland and field margins at lower elevations but where cultivation has extended back into the mountains it probably ranges up to about 2500 feet. The vertical ranges of this mouse and *Peromyscus m. nubiterrae* come together at an elevation of approximately three thousand feet.

Measurements. Ten males: total length (144-194) 161.1, tail (64-80) 71.1, hind foot (20-22) 21; one female: total length 160, tail 67, hind foot 21. *Weights.* Three males: (22.3-24.6) 23.28 grams.

Peromyscus gossypinus megacephalus (Rroads). Rhoads Cotton Mouse.

Twelve specimens from Greenbrier and Fighting Creek near Gatlinburg.

These mice, the largest of the *Peromyscus* group occurring in the Park, were frequently collected in the open woodlands and field margins at low elevations where farming activity has produced brush growth and open forest situations. They probably range up to 2000 feet or higher. In several restricted areas they were found with *Peromyscus leucopus* but data sufficient to determine habitat preferences were not obtained. Two females taken on March 4 contained three embryos each. A male collected on October 15 had enlarged testes. Roundworms were found in the stomachs of several specimens.

Measurements. Ten males: total length (160-204) 180.3, tail (65-97) 75.3, hind foot (21-26) 23.7; five females: total length (161-196) 178.4, tail (63-90) 78.4, hind foot (20-24) 21.4. *Weights.* Three males: (30.25-36.24) 33.44 grams; two females (32.91-39.34) 36.12 grams.

Peromyscus nuttalli nuttalli (Harlan). Northern Golden Mouse.

Thirteen specimens: Greenbrier, Porter's Flats, Fighting Creek.

This species was taken occasionally along the edge of broomsedge fields, brier patches and old fences. It was found up to about 2500 feet elevation. A female collected on October 12 appeared to be through nursing.

Measurements. Seven males: total length (167-193) 177.8, tail (74-93) 86, hind foot (19-20) 19.9; four females: total length (155-182) 170.5. tail (72-89) 82, hind foot (19-20) 19.2. *Weights.* Two males: (20.88-22.56) 21.7 grams; one female: 25.45 grams.

Oryzomys palustris palustris (Harlan). Swamp Rice Rat.

The occurrence of this species in the mountain region is based on one specimen, an immature female, that was found dead on the sill of an old barn situated near a marshy creek in Greenbrier, at an altitude of about 2200 feet. This specimen was obtained on April 3, 1931, and although considerable trapping was done in that vicinity during 1931 and the following year no more were taken. This record is unique in that there seem to be no records of this species occurring above 1000 feet. Its distribution was apparently extended into the mountains as a result of agricultural activities of local residents.

Sigmodon hispidus hispidus Say and Ord. Eastern Cotton Rat.

Six specimens from Greenbrier.

In the mountains cotton rats were found only in one locality; a

heavily overgrown broomsedge field at an elevation of about 1700 feet near Greenbrier. They had well defined runways throughout the field. This species is common near Knoxville. Its distribution was also apparently extended into the mountains as a result of agricultural activities.

Measurements. Three males: total length (207-252) 230.6, tail (92-108) 99.6, hind foot (29-32) 30.6; three females: total length (197-208) 203.6, tail (87-93) 89, hind foot (26-30) 27.6.

Synaptomys cooperi stonei Rhoads. Stone Lemming Mouse.

Twenty-six specimens: Greenbrier, Siler's Bald, Roaring Fork, Spence Field, Buck Prong, and Little River (2900 ft.).

Lemming mice were found in small scattered grassy patches throughout the mountains up to the highest peaks. Generally, they had well defined runways in which grass cuttings were found. Several stomachs examined contained finely chewed grass. A female taken on March 17 contained three embryos about half developed; another taken on March 19 had one embryo near birth; two collected on March 12 and 23 had well developed embryos numbering four and one respectively. These mice were comparatively free of external parasites.

Measurements. Four males: total length (122-136) 127.7, tail (22-27) 24.5, hind foot (20-21) 20.2; five females: total length (120-133) 126.8, tail (20-27) 23.4, hind foot (19-21) 20.6. *Weights.* Three males: (31.2-35.6) 32.37 grams; two females: (32.85-36.) 34.4 grams.

Clethrionomys carolinensis Merriam. Carolina Red-backed Mouse.

Thirty-seven specimens: Mt. Guyot, Clingman's Dome, Spence Field, Buck Fork (4200 ft.), Mt. Collins, Mt. Kephart, Chapman Prong.

These mice are well distributed throughout the mountains at elevations above approximately 3000 feet. In the humid forest they were taken most often among mossy rocks but near Spence Field they were also found on top of the grassy balds. On the latter they were trapped at the bases of isolated shrubs situated in the open grass. In the thick mat of moss which at high altitudes is abundant in the forest their runways were common (fig. 6). During the summer these mice were occasionally seen on the trails at midday. Several stomachs examined contained finely chewed green vegetable material.

A female taken on July 31 contained three embryos about 16.8 mm. in length. Another taken on July 21 contained three embryos about 13 mm. in length and one very small one in the left horn of the uterus. Half-grown individuals were collected on July 31 and August 23.

Warbles (*Cuterebra* sp.) were commonly found in mice of this species, most frequently in males and then nearly always near the testes. In a male freshly caught on July 31 three large warbles were found by the testes alongside of which was a cavity formed by the emergence of one of these larvae and which upon examination was found to contain small, live maggots. In this specimen the right testis was only about half the size of the left.

Measurements. Ten males: total length (138-163) 146, tail (39-53) 45.8, hind foot (19-21) 20; ten females: total length (135-152) 145.4, tail (30-55) 43.6, hind foot (19-21) 20. *Weights.* Six males: (20-29.6) 22.8 grams; four females: (26.6-31.28) 28 grams.

Microtus chrotorrhinus carolinensis Komarek. Smoky Mountain Rock Vole.

Thirty-seven specimens: Mt. Kephart, Chapman Prong, Buck Fork, Newfound Gap, Eagle Rocks Creek, Siler's bald, Smokemont, Sawtooth, Thunderhead.

The Smoky Mountain rock vole is generally distributed throughout the higher regions in the mountains and is most common among the mossy rocks and logs in the high humid forest (fig. 6). On the grassy balds of Thunderhead several were trapped in rock outcrops on the grassy summit. The vertical distribution of this form corresponds with that of the red-backed mouse (*Clethrionomys carolinensis carolinensis*) with which it shares the same habitat. A female with three embryos near birth was taken on March 13. Males taken between July 31 and August 27 had enlarged testes. Two half-grown individuals were collected on October 9. A female trapped along Eagle Rocks Creek was decidedly silver-gray in color on the upperparts and grayish-white underneath The stomach of one taken in September contained blackberry seeds. There is some indication that the abundance of this rodent varies from year to year.

About 65 per cent of the specimens obtained were infested with warbles (*Cuterebra* sp.). Usually from one to three were found around the testes and the underside of the hind legs. One had several ticks (*Ixodes* sp.) attached about its nose. Mites (*Laelaps microti* and *Neoschongastia signator*) were collected from this species and nematodes (*Cheiropteranema* sp.) were found in their intestines and cecae. One individual taken on September 14 had scars and sores on the stomach wall which appeared to be due to a nematode infection.

Measurements. Ten males: total length (144-177) 163.6, tail (46-55) 49.7, hind foot (20-24) 21.9; nine females: total length (147-175) 172, tail (43-56) 50.9, hind foot (20-22) 21. *Weights.* Four males: (26-46.7) 33.7 grams; one female: 28.4 grams.

Pitymys pinetorum scalopsoides (Audubon and Bachman) Mole Pine Mouse.

Thirteen specimens from Cades Cove and Greenbrier.

The pine mouse in certain areas occurred in considerable numbers but was not generally common and its distribution appears to be localized. In Cades Cove they were taken in an open deciduous woods where they had runways under a mat of dead leaves. They were also observed foraging about during the daytime in this locality. In Greenbrier they were collected in tunnels in an apple orchard and in a small marshy area at the edge of a woods. Pieces of grass, decomposed apples, and kernels of corn were found in the runways. A female taken on March 16 had three well developed embryos; another taken on March 24 had two.

Measurements. One male: total length 124, tail 27, hind foot 16; four females: total length (124-126) 124.7, tail (23-28) 26, hind foot (16-18) 17.

Ondatra zibethica zibethica (Linnaeus). Common Muskrat.

A single specimen was collected along the Little Pigeon River about two miles below Greenbrier. At this particular locality muskrats were foraging in a nearby cane patch where they had done considerable damage. They were also feeding on young willow shoots (*Salix* sp.) along the river and would frequently cut off a small bush.

Measurements. One male: total length 596, tail 293, hind foot 80.

Mus musculus musculus Linnaeus. House Mouse.

Three specimens from Greenbrier.

Though most frequently taken around cabins and barns, this introduced species is sometimes found at some distance from human habitations. It is very common in this region.

Measurements. Two males: total length (144-145) 144.5, tail (71-78) 74.5, hind foot (16-19) 17.5.

Rattus norvegicus (Erxleben). Norway Rat.

One specimen from Greenbrier, one from Eagle Rocks Creek.

The Norway rat is found abundantly around buildings and occasionally in rock fences bordering corn fields. The specimen taken along Eagle Rocks Creek was at an elevation of about 3800 feet about five miles from the nearest habitation.

Measurements. One male: total length 314, tail 168, hind foot 39.

Rattus rattus rattus (Linnaeus). Black Rat.

Three specimens from Greenbrier.

This rat was found abundantly around barns in the vicinity of

Greenbrier. White-spotted phases were reported but none were secured.
Measurements. One female: total length 372, tail 174, hind foot 35.

Napaeozapus insignis roanensis (Preble). Roan Mountain Jumping Mouse.

Seven specimens from Eagle Rocks Creek.

The distribution of the jumping mouse is apparently somewhat localized and the species is probably more abundant than the number of specimens secured might indicate. Six of the seven individuals obtained were taken in the humid forest along Eagle Rocks Creek at an elevation of 4000 feet. One was seen at mid-day along the Buck Fork at an altitude of about 3000 feet. These are believed to be the first specimens recorded from Tennessee.

Measurements. Three males: total length (224-246) 232, tail (145-151) 148, hind foot (29-32) 30; two females: total length (217-231) 224, tail (138-145) 141.5, hind foot (30-30) 30.

Sylvilagus floridanus mallurus (Thomas). Eastern Cottontail.

Fourteen specimens from Greenbrier.

The eastern cottontail was found abundant in open woods and broomsedge fields. In the course of a short walk as many as a dozen were counted as they foraged about at twilight. According to local reports rabbits were noticeably less common in Greenbrier several years ago when foxes were more numerous. In 1933 residents asserted that the latter were again invading the region about this settlement which may be due to the increased food supply. During the fall of the same year several rabbits were reported found dead but none were examined. The year previous two specimens were sent to the University of Tennessee where post-mortem examinations were performed to determine if tuleremia was present. The results were positive.

During extended cold spells rabbits frequently hole-up in rock piles for several days while in summer such retreats are utilized to avoid the heat of mid-day. In such situations several specimens were caught by hand. This species was found infested with ticks (*Haemophysalis leporis-palustris*), fleas, and bot fly larvae (*Cuterebra* sp.).

Sylvilagus transitionalis (Bangs). New England Cottontail.

This species has been taken in the mountains of North Carolina north of the Park and also to the south in Georgia. Local people asserted that two kinds of rabbits are found in the park and that one of these which inhabits the higher regions is called the "woods rabbit". Although *transitionalis* was not taken by us it is probable that further investigations will establish its presence in this area.

Odocoileus virginianus virginianus (Boddaert). Virginia Deer.

According to local residents, deer were once common in some sections of the area now included in the Park but due to over-hunting and possibly disease they now occur infrequently. Several individuals have been seen and tracks have been found near Cades Cove and Cosby and until the past few years, when hunting has been prohibited, several were taken annually in the Butler Tract near Gregory Bald. Eb Whaley who has spent the greater part of his life in the vicinity of Greenbrier states that as far back as he can remember deer were rare. He recalls that as a boy a buck was shot along the stream now called the Buck Fork. We have received information from a number of individuals referring to disease among deer and it is possible that this factor may have played an important part in their disappearance.

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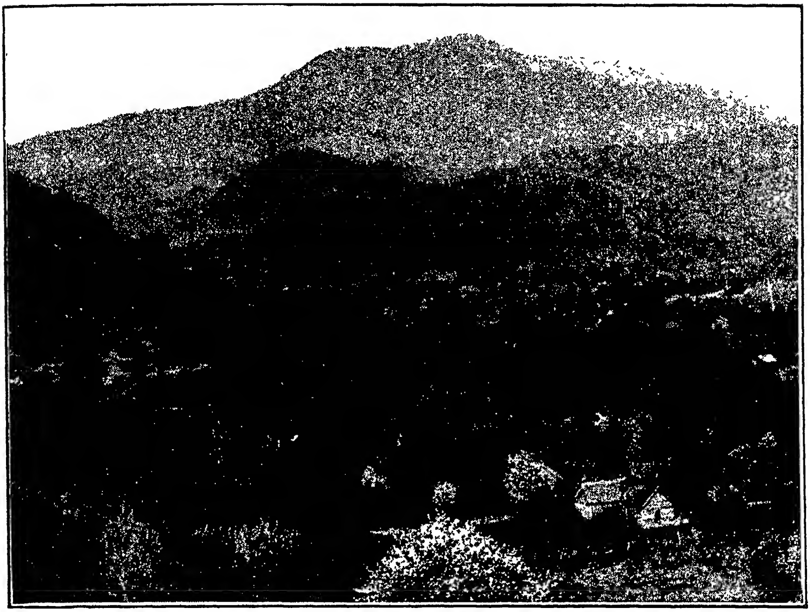


Fig. 1. View of Greenbrier Cove in the spring of 1931. The mountain in the background is the Greenbrier Pinnacle.

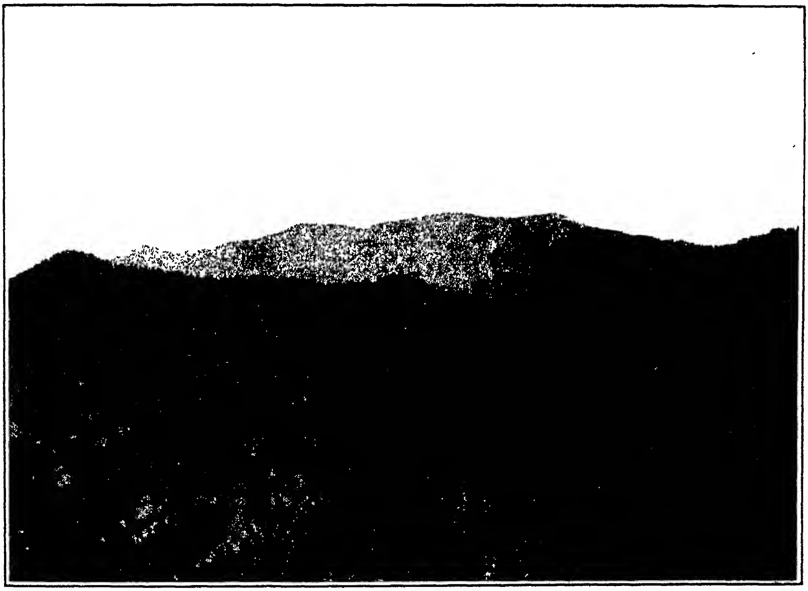


Fig. 2. Mt. Le Conte from the Appalachian Trail near Newfound Gap. The light area in the lower right is a ridge covered with mountain laurel. Such ridges are locally called "slicks".

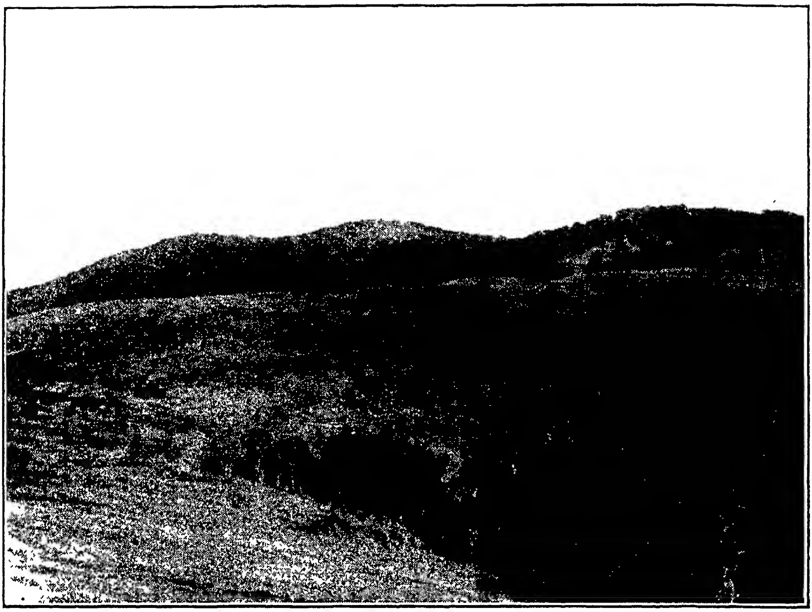
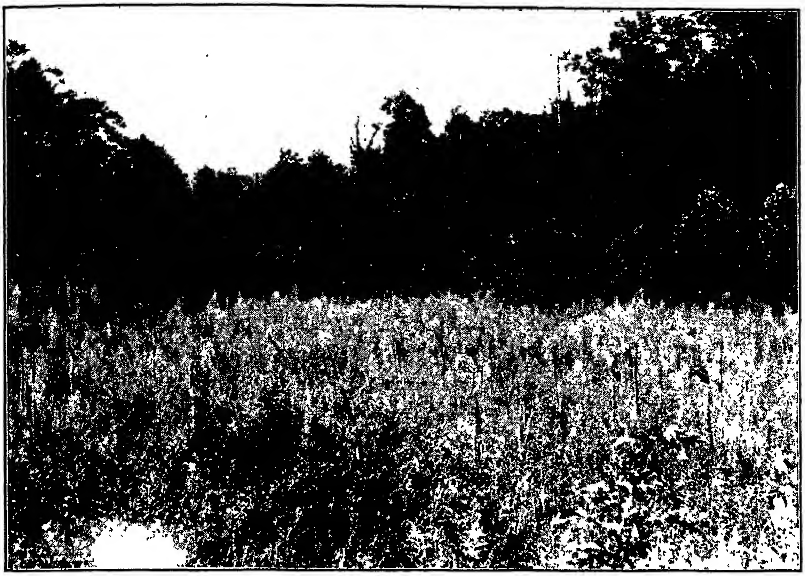


Fig. 3. A grassy "bald" near Thunderhead Mt.—September, 1934.

Fig. 4. Trail along the Buck Fork in the summer of 1931. The dense vegetation bordering the trail is chiefly rhododendron (*Rhododendron* sp.).



Cornfield one year after cultivation was discontinued. Blight-killed chestnut trees are visible above shrub foliage.

g. o. Habitat study at 4500 feet elevation in which *Peromyscus maniculatus nubiterrae*, *Clethrionomys carolinensis*, *Microtus chrotorrhinus carolinensis*, and *Sorex fumeus* were frequently taken.

Vol 5, No 7 Sept 20, 1938

BULLETIN

OF THE

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Chicago, Illinois Published by the Academy

THE SUBSPECIES OF THE COPPERHEAD, *AGKISTRODON MOKASEN* BEAUVOIS

BY

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Studies leading toward a monographic treatment of the American species of *Agkistrodon* have led to the conclusion that the copperhead, *A. mokasen* Beauvois, is represented by three geographic races. One of these, a southwestern form, has been described under the name *laticinctus* (Gloyd and Conant, 1934). Since the completion of the longer paper has been delayed, it seems desirable to publish comments on the taxonomy involved and preliminary diagnosis of the remaining two forms which occur in the Mississippi Valley and eastern states.

When Stejneger and Barbour (1917, p. 76-77) showed that the name *contortrix* of Linné (1766) is applicable not to the copperhead but to a species of *Heterodon,* they adopted (op. cit., p. 106) the next oldest name, *mokasen* of Beauvois (1799), for the copperhead. Since Beauvois (pp. 370, 381) did not mention a specific locality nor give a description of the "mokasen" on which he based his genus *Agkistrodon,* it is not clear from his paper whether his name referred to the copperhead or to the cottonmouth moccasin. Although he did not distinguish his species from *piscivorus* of Lacépède (1789, Tab. Meth., p. 130), this name probably was known to him for he mentioned (p. 379) Lacépède's classification of serpents with some critical comments. Daudin (1803, p. 358, pl. 70, fig. 3), however, did distinguish between

the two species, using *piscivorus* of Lacépède for the cottonmouth and *mokasen* of Beauvois for the copperhead. It seems, therefore, that the present application of Beauvois' name to the species does not need to be modified. In the absence of a description and a stated locality, however, it is difficult to determine to which of the two eastern subspecies the original name should be restricted.

If *mokasen* as a subspecific name be restricted to the more northern race, a new name must be proposed for the southern subspecies; if restricted to the more southern race, the name *cupreus* of Rafinesque (1818, p. 84) is available for the northern subspecies. Since Beauvois first mentioned the "mokasen" (p 370) along with a number of southern snakes, it is probable that he had in mind representatives of the more southern form. For this reason the present writers prefer the latter alternative and propose that the three subspecies of the copperhead be designated as follows:

Agkistrodon mokasen mokasen Beauvois. Southern Copperhead.

Agkishodon mokasen* Beauvois, Trans. Amer. Philos. Soc, vol. 4, 1799, p. 370. Type locality not designated. Neotype: Chicago Acad. Sci. No. 5089, Gentilly, Orleans Parish, Louisiana.

Diagnosis. Coloration generally pale and usually with a noticeable pinkish tinge in life. Viewed from above, the pattern consists of a series of hour-glass-shaped crossbands, conspicuously narrow at the midline (rarely more than 2 or 3 scales wide); viewed from the side, the crossbands resemble triangles, roughly equilateral, with acute basal angles rounded off on the second or third row of scales, and bearing an upward extension at the apex which, in this subspecies, often fails to meet the similar extension from the opposite side. Belly pale, not heavily marked. A distinct series of ventro-lateral blotches, the more conspicuous of which alternate with the bases of the triangles. Fig. 1.

Range. The coastal plain of the Gulf States, from Victoria County, Texas, north to northeastern Texas, central Arkansas, southern Illinois, and east-central Alabama; the Atlantic coastal plain and lower Piedmont areas north to southern Maryland, exclusive of peninsular Florida.

Agkistrodon mokasen cupreus (Rafinesque). Northern Copperhead.

Scytalus cupreus Rafinesque, Amer. Journ. Sci., vol. 1, 1818, p. 84. Type locality Fishkill, New York. Neotype: Mus. Zool. Univ. Michigan No. 81758, 2 miles south of Fishkill, Dutchess County, New York.

*Typographical error.

Fi. 1 Pattern of Agk r l m k i m l i a Cnc Acad Sc N 5(5) Cnt lls Onl r P h L

Fi. 2 Pattern of A k i tr d n mok isen cupreu Mus Z l Univ Michigan N 7(10 Ramap M untains New Jersey n ar Suffern New Y rk

Fi. Pattern of Agki tr d n mok isen laticin tu Type specimen Mus Z l Uni Michigan N 75599 26 miles n rthwest f San Anton Bexar County Texas

GLOYD AND CONANT· SUBSPECIES OF COPPERHEAD

Diagnosis. Coloration darker in general than that of *A. m. mokasen;* often reddish brown or chestnut, sometimes with little contrast between pattern and ground color; specimens from some localities are densely stippled with gray or marked with small round or irregular spots between the crossbands. Viewed from above, the crossbands are somewhat spool-shaped, less constricted mid-dorsally (3 to 5 scales at midline); viewed from the side, they resemble isosceles or equilateral triangles with less acute basal angles and with the upward extension of the apex usually meeting the blotch of the opposite side. Belly usually darker, more or less heavily mottled with gray or black. Ventro-lateral blotches distinct, some alternating with the bases of the triangles Fig. 2.

Range. Eastern Oklahoma and eastern Kansas; higher areas of west-central and northwestern Arkansas, Missouri (except southeastern part), north to central Illinois, central Indiana, southern and eastern Ohio, Pennsylvania, and southeastern New York; Appalachian highlands from the Tennessee River and northeastern Alabama to eastern Massachusetts. Specimens intergrading with ***mokasen*** are known from northeastern Arkansas, southeastern Missouri, southern Illinois and northwestern South Carolina.

Agkistrodon mokasen laticinctus Gloyd and Conant. Broad-banded Copperhead.

Agkistrodon mokasen laticinctus Gloyd and Conant, Occas. Papers Mus. Zool., Univ. Michigan, No. 283, 1934, p. 2. Type locality 26 miles northwest of San Antonio, Bexar County, Texas. Holotype: Mus. Zool. Univ. Michigan No 75599.

Diagnosis. Coloration bright of tone with marked contrast between pattern and ground color; crossbands strikingly broad (7 to 14 scales wide on sides at first row of scales), only slightly constricted mid-dorsally (4 to 8 scales wide at midline), and extending downward laterally to the ventrals where instead of alternating they blend with the ventro-lateral pattern of three more or less conspicuous blotches to each crossband. Fig. 3.

Range. Western and central Texas, from Jeff Davis, Reeves and Brewster Counties eastward to Colorado County; north through central Oklahoma to Cowley County, Kansas. It intergrades with ***cupreus*** in Okmulgee, Tulsa and Kay Counties, Oklahoma, and probably with *mokasen* in southeastern Texas.

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Vol. 5 No. 8

BULLETIN

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A SYNOPSIS OF NORTH AMERICAN BIRDS OF PREY AND THEIR RELATED FORMS IN OTHER COUNTRIES

By

MAJOR L. R. WOLFE, U. S. Army

CHICAGO
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BULLETIN

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A SYNOPSIS OF NORTH AMERICAN BIRDS OF PREY AND THEIR RELATED FORMS IN OTHER COUNTRIES

By

Major L. R. Wolfe, U. S. Army

During the past few years I have devoted considerable time to a study of the world distribution of birds of prey, and one point of particular interest which has been developed is the similarity between many North American forms and their closely related geographical races which occur on other continents. To those interested in the popular or semi-scientific study of birds the term geographical race or subspecies suggests a difference in color, size, or some other slight variation due to climatic differences of habitat through one continuous range, or closely adjacent ranges, and indicates no relationship with European or Asiatic forms. On the contrary, however, many North American birds represent geographical races of species found in other parts of the world, and the present ranges of many subspecies may be as widely separated as two continents. The consideration of geographical forms, therefore, assumes a much broader aspect and greater ecological significance when one realizes that certain birds from such widely separated places as Chile, Greenland, Australia, and South Africa represent the same species and can be distinguished only by slight differences in size or in the color or plumage. It is also interesting to note that some geographical races representing a single species are found only in the Americas and not in the Old World. Some groups are confined wholly to the Old World and never occur in America, others are Holarctic but never found south of the equator, and still others are distributed throughout the world.

Although the systematic arrangement of the species embraced by the order Falconiformes has been the subject of a vast amount of

research, our knowledge is still far from complete and, in some instances, unsatisfactory. Nearly all species in this order show considerable individual variation in plumage. Juvenile specimens often vary more than adults and a confusing problem is presented by the successive changes of plumage through which they pass during the first two or three years. Another factor which hinders proper classification is that much of the material available for study represents migrating birds and has little or no value in the determination of geographical forms. Hence some species are especially difficult to study and authorities are unable to agree on their classification.

In this paper it is intended to outline very briefly the distribution of the species and subspecies of birds of prey which occur in North America and their geographic races in other parts of the world. The major characters which separate the forms are indicated but no attempt has been made at complete descriptions. North American forms in the following list are preceded by an asterisk (*); among these are nine species which have no recognized geographic races. The sequence followed is that of the last A. O. U. Check List (1931).

I desire to express my thanks and appreciation to Rudyerd Boulton of the Field Museum of Natural History for permission to make use of the excellent collection of skins in that institution during the progress of this study, and I am equally indebted to Dr. H. K. Gloyd of the Chicago Academy of Sciences for his assistance in the preparation of the manuscript and maps.

THE VULTURES

The American vultures are distinct from all of the Old World forms and, while there is one South American species, *Cathartes urubitinga*, that is very closely related to the turkey vulture (and not distantly related to the black vulture), they have no close relatives in any other part of the world. The turkey vulture, the most widespread species, occupies one continuous area from southern Canada across the United States from east to west, and south to the southern tip of South America. Throughout this immense range there is a gradual change in size and in the color of the plumage. The largest individuals occur in the northeastern United States and those in the west average smaller. Southward there is a gradual decrease in size and a gradual darkening of plumage until in the tropical zones of South America the birds are comparatively small and much blacker than those from the north. The size gradually increases again toward the colder climates of South America and in Chile the resident form is nearly as large as the North American bird. This is strikingly in

accordance with the general rule for size variation in birds and mammals, known as the Bergmann Rule. Like many other species the turkey vulture has been separated into several geographical races and, while there is only a gradual change and no exact line of demarcation between the various forms, each is easily recognized when birds from within each range are compared.

The black vulture is a more tropical species and shows much less variation within its range. There is apparently no difference in color but the South American birds are said to be smaller, though even this has been questioned.

*** Eastern Turkey Vulture.** *Cathartes aura septentrionalis* WIED.

Range: Eastern North America north to southern Canada and west to central Ontario, Illinois, eastern Iowa, Arkansas, and Louisiana

This is the largest form of the species. The plumage is more brownish black than that of the southern forms and the wing coverts are more or less margined with pale brown. The tail is relatively long and the wings are large.

*** Western Turkey Vulture.** *Cathartes aura teter* FRIEDMANN.

Range: Austral zones of Western North America east to the range of, and intergrading with, the eastern race; southward to southern Lower California and the table lands of northern Mexico.

This recently described race (Friedmann, 1933) is similar in color to the eastern form but intermediate in size between that and the Mexican form. It has relatively small wings like the latter but a longer tail like the eastern subspecies.

*** Mexican Turkey Vulture.** *Cathartes aura aura* (LINNAEUS).

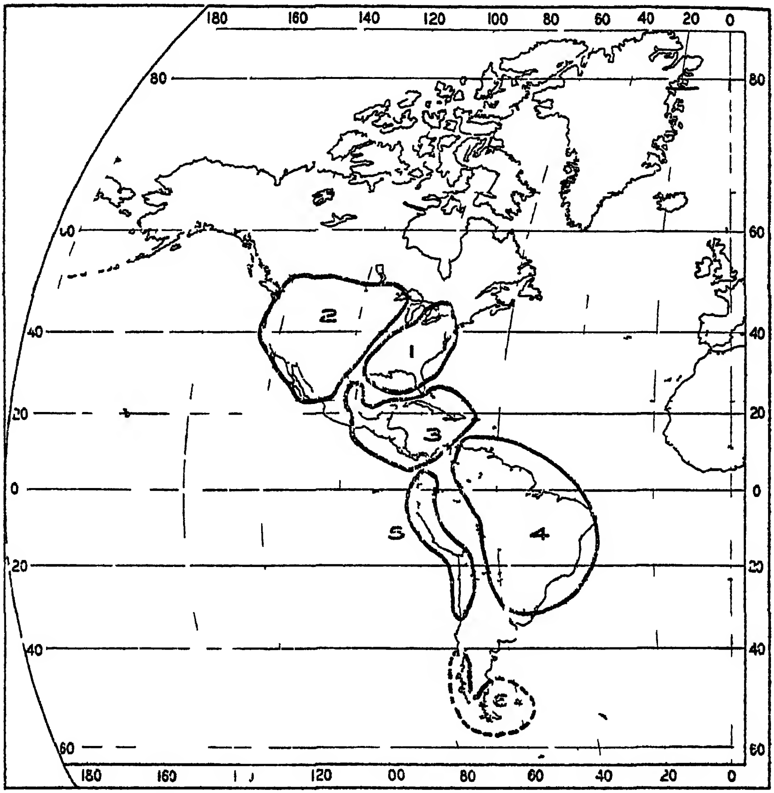
Range: From the lower Rio Grande valley of Texas (Brandt, 1936) south through Mexico and Central America to Panama and northern Columbia; the Bahamas, Cuba, Isle of Pines, Jamaica, Puerto Rico, and the Virgin Islands. It possibly occurs in southern Florida.

This race is smaller than either of the northern forms. The color is blacker, and there are fewer brown edgings to the feathers; the wings are smaller and the tail is comparatively short.

Brazilian Turkey Vulture. *Cathartes aura ruficollis* SPIX.

Range: Eastern South America from Colombia, the Guianas, Venezuela, and Brazil, south through Paraguay and northern Argentina; Trinidad and adjacent islands.

Slightly smaller than the Mexican race. The plumage is blacker and is glossed with blue and purple iridescence.



DISTRIBUTION OF THE TURKEY VULTURE
1—*Cathartes aura septentrionalis*, 2—*C a teter*, 3—*C a aura*, 4—*C a ruficollis*, 5—*C a jota*, 6—*C a falklandica*

Chilean Turkey Vulture. *Cathartes aura jota* (MOLINA).

Range South America west of the Andes and south to central Chile.

A larger form, nearly as large as the eastern North American race, but the plumage is blacker and similar to that of the Brazilian form.

Falkland Turkey Vulture. *Cathartes aura falklandica* (SHARPE).

Range Falkland Islands and the adjacent coast of South America, north on the Chilean coast to Lat 40°

A smaller race, similar in size to *ruficollis*. The plumage is black but the median wing coverts and secondaries are distinctly shaded and edged with gray

*** Black Vulture.** *Coragyps atratus atratus* (BECHSTEIN).

Range: North America from Kansas, southern Illinois, southern Indiana, and Maryland to the Gulf of Mexico, south through Mexico and Central America to Panama.

Slightly larger than the South American form.

Brazilian Black Vulture. *Coragyps atratus foetens* (LICHTENSTEIN).

Range: South America to about Lat. 40° on the east coast and to Chiloe Island on the west coast; Trinidad and adjacent islands.

This race has been described as slightly smaller and with a shorter tarsus than the northern form. In a recent paper on American vultures, Friedmann (1933) concludes that this is not a valid form and that individuals can not be separated from North American birds. The two races are recognized by nearly all European ornithologists, however. I have been able to examine only a few skins of this race but in my collection a small series of eggs taken in Chile, Brazil, Paraguay, and Trinidad have an average measurement of 70.5 x 50.0 mm. whereas the eggs of the North American black vulture average about 77.0 x 53.0 mm. With this large difference in the size of the eggs, it would appear that there is considerable difference in the size of the birds.

*** California Condor.** *Gymnogyps californianus* (SHAW).

Range: California from the south-central coastal ranges to northern Lower California.

There are no geographical races of this species.

WHITE-TAILED KITES

The white-tailed kite is represented by two forms, one in North and one in South America. The genus is cosmopolitan, however, and there are closely related species in Africa, India, the East Indies, and Australia.

*** White-tailed Kite.** *Elanus leucurus majusculus* BANGS AND PENARD.

Range: Western California, from the Sacramento Valley to northern Lower California; of rare occurrence from southern Texas through the Gulf States to South Carolina and Florida.

In comparison with the South American race this form is larger, the tail is longer, the coloration is darker above and the black wing patches are relatively larger.

Southern White-tailed Kite. *Elanus leucurus leucurus* (VIEILLOT).

Range: South America, from Venezuela to central Chile and south-central Argentina.

SWALLOW-TAILED KITES

The swallow-tailed kite represents a genus that is found only in the Americas and, as in other species, the more tropical birds are smaller and slightly darker. The size increases again in the more temperate zones of South America. A very unusual thing about its distribution is that individuals from the extreme southern part of the range can not be distinguished from those from the northern part. For the purposes of nomenclature the southern birds are regarded as belonging to the Central American subspecies.

*** Swallow-tailed Kite.** *Elanoïdes forficatus forficatus* (LINNAEUS).

Range: South Carolina and Florida along the Gulf Coast to Louisiana.

Slightly larger than the southern form. There is less white on the neck and there is a difference in the shade of black on the back.

Southern Swallow-tailed Kite. *Elanoïdes forficatus yetapa* (VIEILLOT).

Range: From Costa Rica south to Paraguay and northeastern Argentina.

Differs from the North American form in being slightly smaller, in having bottle-green iridescence of the scapulars, and in that the white on the hind neck extends farther back.

MISSISSIPPI KITE

This kite represents a genus that is found only in America. It has no geographic forms but there is a closely related genus in South America.

*** Mississippi Kite.** *Ictinia misisippiensis* (WILSON).

Range: Oklahoma, central Kansas, and South Carolina south to southern Texas and northern Florida

EVERGLADE KITES

The everglade kite or snail kite, as it is sometimes called, has been separated into four geographical races and has a rather unusual distribution in that the tropical form which occurs in eastern Mexico and Guatemala is larger than the more northern form.

*** Everglade Kite.** *Rostrhamus sociabilis plumbeus* RIDGWAY.

Range: Florida.

A long wing and small bill characterize this form. The plumage is paler above and the throat and head are more plumbeous than in the typical race.

Southern Everglade Kite. ***Rostrhamus sociabilis sociabilis*** **(VIEILLOT).**

Range: Eastern Panama south to Paraguay and central Argentina.

The smallest race. The wings are comparatively short, the bill large, and the color more sooty black than that of the Florida form.

Cuban Everglade Kite. ***Rostrhamus sociabilis levis*** **FRIEDMANN.**

Range: Cuba and the Isle of Pines.

Characterised by having the long wings of the Florida race and the large bill of the South American form.

Mexican Snail Kite. ***Rostrhamus sociabilis major*** **NELSON AND GOLDMAN.**

Range: Lowlands of eastern Mexico and Guatemala.

The largest form of the species. The wings and tail are longer, and the bill is much larger and heavier, than those of the other forms.

GOSHAWKS

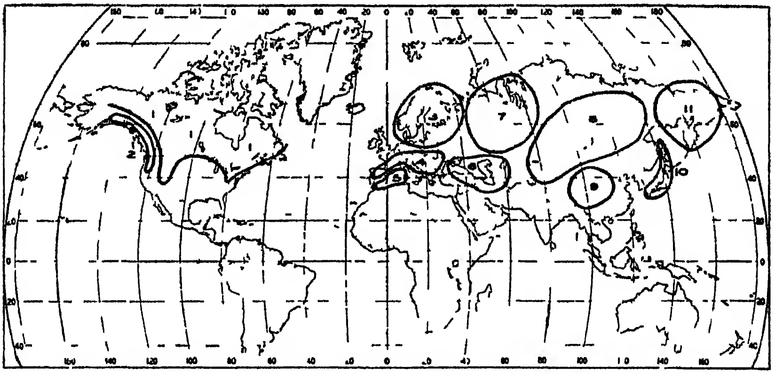
The goshawk is a very wide-spread species, occurring throughout almost all Europe and Asia as well as in North America, but not found in the southern hemisphere. As in several other species of similar distribution, it has been separated into numerous geographical races and few ornithologists agree as to the exact status of several forms.

Recent authorities unite the genus *Astur* with *Accipiter* (e.g., Peters, 1931) because the characters which have been used to distinguish the two genera are very slight and are, in fact, not distinctive in several of the intermediate species that occur in other parts of the world. The genus *Accipiter* is supposed to have the tarsi and toes longer and more slender and to have the middle toe much longer than the others. The American species, however, are easily separated by distinctive characters and for this reason both genera are retained in the A. O. U. check list of 1931.

* **American Goshawk.** ***Accipiter gentilis atricapillus*** **(WILSON).**

Range: Northwestern Alaska to Newfoundland, south to New Mexico in the Rocky Mountain region, to northern Wisconsin and Michigan in the central states, and to the mountains of southern Pennsylvania in the east.

The American forms differ from those of the Old World in being more bluish or slate-colored above, in having black shaft stripes and freckled or vermiculated underparts. The European and Asiatic forms are more brown above with underparts more or less barred.



DISTRIBUTION OF THE GOSHAWK

1—*Astur gentilis atricapillus*, 2—*A. g. striatulus*, 3—*A. g. gentilis*, 4—*A. g. gallinarum*, 5—*A. g. arrigonii*, 6—*A. g. caucasicus*, 7—*A. g. buteoides*, 8—*A. g. schvedowi*, 9—*A. g. khamensis*, 10—*A. g. fujiyamae*, 11—*A. g. albidus*

*** Western Goshawk.** *Accipiter gentilis striatulus* RIDGWAY.

Range: Boreal zones of the Pacific Coast from Cook Inlet to northern California.

Plumage above much darker than that of the eastern form; underparts darker and more conspicuously and densely marked.

Common Goshawk. *Accipiter gentilis gentilis* (LINNAEUS).

Range: Scandinavian Peninsula, northern Europe and western Russia.

Ashy brown above; white below, barred with blackish brown; tail distinctly banded.

Southern Goshawk. *Accipiter gentilis gallinarum* BREHM.

Range: Central and western Europe, south to the Balkans.

Slightly smaller than the typical form. Juvenile specimens are darker below and the stripes are wider and more ochraceous.

Russian Goshawk. *Accipiter gentilis buteoides* MENZBIER.

Range: Northeastern Russia and Siberia east to the Yenisei River. Southern limits unknown.

Slightly larger and paler above than the typical form. The back is more bluish slate-gray in color and the cross-bars below are finer and farther apart.

Sardinian Goshawk. *Accipiter gentilis arrigonii* KLEINSCHMIDT.

Range Southern coast of Spain and the islands of Sardinia and Corsica
Smaller and very much darker than the typical form.

Siberian Goshawk. *Accipiter gentilis schvedowi* MENZBIER.

Range: Northern and central Asia east to the Amur River and south to the Himalayas and northwestern China

Slightly smaller, more gray with little or no tinge of brown; barring below finer and paler than in the typical form.

Caucasian Goshawk. *Accipiter gentilis caucasicus* (KLEINSCHMIDT).

Range The Crimean Peninsula, Caucasian and Caspian regions and Asia Minor.

A small, dark-colored form resembling the Sardinian goshawk.

Tibetan Goshawk. *Accipiter gentilis khamensis* BIANCHI.

Range: South-central Asia including Tibet and western China

Similar in size to the Siberian goshawk but plumage very much darker. General coloration darker above and more blackish brown than that of the typical form.

Japanese Goshawk. *Accipiter gentilis fujiyamae* SWANN AND HARTERT.

Range: Japan and Sakhalin

The smallest form of the species. Very dark with the underparts heavily barred and more black above than brown.

White Goshawk. *Accipiter gentilis albidus* MENZBIER.

Range: Northeastern Siberia and Kamchatka.

This race differs from all other forms in that the plumage is nearly white and the markings are very faint.

SHARP-SHINNED HAWKS

This species has no geographical forms other than those in North America and the West Indies, but the European sparrow hawk, *Accipiter nisus*, is a closely related species and its numerous subspecies occur over nearly all Europe, northern Africa, and Asia.

*** Sharp-shinned Hawk.** ***Accipiter striatus velox*** **(WILSON).**

Range: Northwestern Alaska to Newfoundland and south, in suitable localities, to the Gulf States and Arizona.

Slaty blue above with head and wing coverts slightly darker; underparts white, barred with pale rufous; tail slaty, barred with dark bands and narrowly tipped with white.

Cuban Sharp-shinned Hawk. ***Accipiter striatus fringilloides*** **VIGORS.**

Range: Cuba.

Smaller and more slender; underparts nearly white; cheeks rufous.

Santo Domingan Sharp-shinned Hawk. ***Accipiter striatus striatus*** **VIEILLOT.**

Range: Dominican Republic and Haiti.

Dark gray above with lower abdomen and thighs white; sides barred with brown.

Puerto Rican Sharp-shinned Hawk. ***Accipiter striatus venator*** **WETMORE.**

Range: Puerto Rico.

Similar to the Santo Domingan form but darker above and with more color below.

COOPER'S HAWK

*** Cooper's Hawk.** ***Accipiter cooperi*** **(BONAPARTE).**

Range: British Columbia through central Alberta to Quebec and southward over most of the United States to northern Mexico.

There are no subspecies of Cooper's hawk. A western form, originally described by Swainson in 1831, was claimed to differ in that the females were more rufous on the thighs and that the markings of the underparts were denser and more deeply color. Ridgway in 1876 pointed out that the western birds were darker colored throughout, the brown markings occupying larger areas and the white portions of less pure color but that there were too many individual variations to warrant the consideration of two races.

RED-TAILED HAWKS

The genus *Buteo* represents a very large group of round-winged, sailing hawks found in all parts of the world except Australia. All species are similar in habits but each has a great deal of individual

variation in plumage. In spite of years of study the exact status of many forms is not yet understood. This is particularly apparent with several races which occur in eastern Europe and central Asia.

The red-tailed hawk, a strictly American species, has the widest distribution of any of the New World buteos. As in numerous other species there is a decrease in size and a darkening of plumage in the more southern forms.

* Eastern Red-tailed Hawk. *Buteo borealis borealis* (GMELIN).

Range: From the Mackenzie district of the northwest Territories, northern Ontario and Newfoundland south to northern Florida; west to the Rocky Mountain region and south through central Texas and the Gulf States.

The name *Buteo jamaicensis* has been recently used (Peters, 1931) to replace *Buteo borealis* on the grounds of line priority. The original description, however, is questionable and not sufficiently clear and, since that name was discarded by the A. O. U. committee on nomenclature many years ago, preference is here given to *borealis*.

Typically the red-tailed hawk is characterized by a brick red tail, usually with subterminal black bar but no other markings. The underparts are buffy white with flanks and abdomen distinctly streaked with blackish brown.

* Floridan Red-tailed Hawk. *Buteo borealis umbrinus* BANGS.

Range: Southern Florida, Cuba, and the Isle of Pines.

Darker above than the eastern form; throat and breast marked with broad stripes of chocolate brown.

* Krider's Hawk. *Buteo borealis krideri* HOOPES.

Range: North-central Great Plains region, from central Alberta and Saskatchewan south to east-central Wyoming and central Minnesota.

A very light colored form. Upperparts brownish gray with more or less white on head, neck and scapulars; underparts almost entirely white; tail white or nearly so. There is much variation in the plumage of this subspecies and few individuals can be considered typical.

* Western Red-tailed Hawk. *Buteo borealis calurus* CASSIN.

Range: Southeastern Alaska and western Mackenzie, south to southern Lower California and northern Mexico, and east to the Great Plains.

This form is characterized by a barred tail, which shows more or less red, and by barred flanks. The general coloration is much darker than that of the eastern form, although there is much variation and some individuals are nearly black.

DISTRIBUTION OF THE RED-TAILED HAWK

1—*Buteo borealis borealis*, 2—*B. b. umbrinus*, 3—*B. b. krideri*, 4—*B. b. calurus*, 5—*B. b. alascensis*, 6—*B. b. fuertesi*, 7—*B. b. fumosus*, 8—*B. b. socorroensis*, 9—*B. b. costaricensis*, 10—*B. b. jamaicensis*.

* Alaskan Red-tailed Hawk. *Buteo borealis alascensis* GRINNELL.

Range: The Pacific slope from Yakutat Bay to the Queen Charlotte Islands

The coloration of this form is similar to that of the western red-

tail but somewhat darker in tone. The birds are distinctly smaller. Although not listed in the A. O. U. Check List, this form is recognized by most authorities.

* **Texan Red-tailed Hawk.** *Buteo borealis fuertesi* SUTTON AND VAN TYNE.

Range: Southwestern Texas, southern New Mexico, northern Chihuahua, and Coahuila.

This is a light colored race somewhat similar to Krider's hawk but with darker upperparts and bright rufous tail with little or no white.

Tres Marias Red-tailed Hawk. *Buteo borealis fumosus* NELSON.

Range: Tres Marias Islands.

Upperparts dark with more rufous on the sides; thighs heavily barred with brown.

Socorro Red-tailed Hawk. *Buteo borealis socorroensis* NELSON.

Range: Socorro Island, off west coast of Mexico.

A rather small form with upperparts dark and underparts uniformly light cinnamon; flanks deep vinaceous cinnamon, indistinctly barred.

Central American Red-tailed Hawk. *Buteo borealis costaricensis* RIDGWAY.

Range: Southern Mexico and Guatemala, south to western Panama.

Smaller than the northern forms; tail uniform rufous with one narrow subterminal band; flanks light rufous instead of barred.

Jamaican Red-tailed Hawk. *Buteo borealis jamaicensis* (GMELIN).

Range: Jamaica, Haiti, Puerto Rico, and other islands of the West Indies.

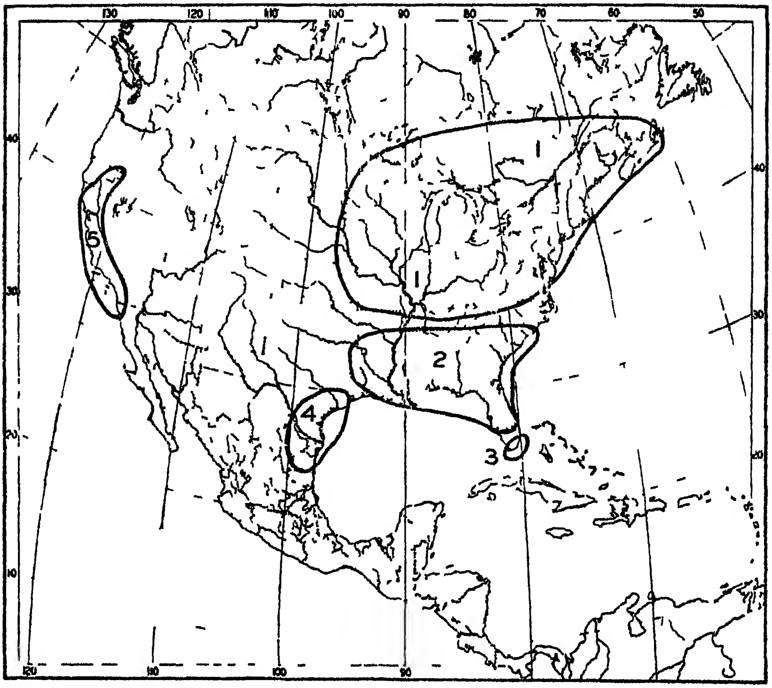
A very small form; sooty brown above; tail red with black band; chest and abdomen with ferruginous streaks.

HARLAN'S HAWK

* **Harlan's Hawk.** *Buteo harlani* (AUDUBON).

Range: Northwestern British Columbia, southwestern Yukon and adjoining regions.

The typical coloration is nearly uniform sooty black, more or less speckled with white, tail mottled or marbled with longitudinal streaks.



DISTRIBUTION OF THE RED-SHOULDERED HAWK

1—*Buteo lineatus lineatus*, 2—*B. l. alleni*, 3—*B. l. extimus*, 4—*B. l. texanus*, 5—*B. l. elegans*

Strictly typical plumage is rarely found but the mottled tail is the best distinguishing character in any plumage.

For a good many years this species was regarded as a form of the red-tailed hawk and to it was allocated a breeding range in southern Louisiana and the Gulf States. This supposition as to breeding range was found to be an error and its specific status is now recognized (Peters, 1931).

RED-SHOULDERED HAWKS

*** Eastern Red-shouldered Hawk.** ***Buteo lineatus lineatus*** **(GMELIN).**

Range: From the eastern edge of the Great Plains east through Ontario, southern Quebec and Nova Scotia, south to southern Kansas, Tennessee and North Carolina.

Reddish brown above with lesser wing coverts bright chestnut; underparts rufous brown indistinctly barred with white; tail black, banded with white.

* **Floridan Red-shouldered Hawk.** *Buteo lineatus alleni* RIDGWAY.

Range Lower Austral zones from Oklahoma, Arkansas and eastern Texas to South Carolina and southeastern Florida.

Similar in color to the eastern race but much smaller.

* **Insular Red-shouldered Hawk.** *Buteo lineatus extimus* BANGS.

Range The southeastern tip of Florida and the Florida Keys

Slightly darker and much smaller than the preceding form.

* **Texan Red-shouldered Hawk.** *Buteo lineatus texanus* BISHOP

Range. Coastal regions from south-central Texas into Tamaulipas, Mexico

As large or larger than the typical form. Plumage darker and breast more spotted with buff; head and neck more rufous

* **Red-bellied Hawk.** *Buteo lineatus elegans* CASSIN.

Range Austral zones of Pacific slope from northern California to northern Lower California

Much darker than the typical form; chest and breast uniform rufous.

BROAD-WINGED HAWKS

The broad-winged hawk occurs rather commonly throughout eastern North America and in this area there are apparently no significant geographical variations in size or coloration, although dark color phases are not uncommon. On the other hand, in the comparatively small area of the West Indies there are four insular races. In Central and South America the broad-winged hawk is replaced by *Buteo magnirostris*, a closely related species of wide distribution, which has been separated into a great many geographical forms.

* **Broad-winged Hawk.** *Buteo platypterus platypterus* (VIEILLOT).

Range· Central Alberta, Ontario, and southern Quebec south to central Texas and Florida

The typical form is characterized by dark brown plumage with lighter edgings above; tail brownish black with two bands.

Cuban Broad-winged Hawk. *Buteo platypterus cubanensis* BURNS.

Range Cuba, the Isle of Pines, and possibly Puerto Rico

Slightly smaller than the typical form and lacking the gray phase of upper plumage; more heavily marked on the thighs and lining of wings

Antillean Broad-winged Hawk. ***Buteo platypterus antillarum*** **CLARK.**

Range: St Vincent, Grenada, and the larger Grenadine Islands.

Smaller than the Cuban form; throat generally darker and the barring on the thighs narrower.

Rivieri's Broad-winged Hawk. ***Buteo platypterus rivieri*** **VERRILL.**

Range: Lesser Antilles from Dominica to Santa Lucia.

Differs from the preceding in being darker and more sooty above and more heavily barred below.

Antiguan Broad-winged Hawk. ***Buteo platypterus insulicola*** **RILEY.**

Range: Antigua Island.

Smaller than the other subspecies. Much lighter than the Antillean broad-wing, with the bars below narrower and less sharply defined.

SWAINSON'S HAWK

*** Swainson's Hawk.** ***Buteo swainsoni*** **BONAPARTE.**

Range: Western North America from British Columbia, the northwestern Mackenzie district and Manitoba, south to northern Mexico and southeastern Arizona.

Swainson's hawk is one of the few buteos which do not have distinctive subspecies. There is much individual variation and melanism is of frequent occurrence but no geographical races have been recognized.

ZONE-TAILED HAWKS

*** Zone-tailed Hawk.** ***Buteo albonotatus albonotatus*** **KAUP.**

Range: Lower California, southern Arizona, southern New Mexico, and southwestern Texas, south to Panama.

Black with a slaty shade on chest and shoulders; tail black with three grayish white bars.

Southern Zone-tailed Hawk. ***Buteo albonotatus abbreviatus*** **CABANIS.**

Range: Pearl Island and northern Colombia east to Surinam.

Smaller than the northern subspecies. Plumage blacker and without the slaty shade on chest and shoulders.

WHITE-TAILED HAWKS

*** Sennett's White-tailed Hawk.** ***Buteo albicaudatus hypospodius*** **GURNEY.**

Range: Lower Rio Grande valley south through Mexico and Central America to northwestern Colombia and Venezuela.

Slightly smaller and paler than the typical form; the cross-bars on underparts and tail finer and more broken.

Guianan White-tailed Hawk. ***Buteo albicaudatus colonus*** **BERLEPSCH.**

Range: Northern Colombia east of the mountains, east to Surinam.

Much smaller than either of the other forms. Head and neck darker and bars on tail darker and wider.

White-tailed Hawk. ***Buteo albicaudatus albicaudatus*** **VIEILLOT.**

Range: Southern South America from northwestern Argentina and southern Brazil southward.

Larger and darker than Sennett's white-tailed hawk.

SHORT-TAILED HAWK

*** Short-tailed Hawk.** ***Buteo brachyurus*** **VIEILLOT.**

Range: Southern Florida and eastern Mexico, south through Central America to Brazil, Peru, and Paraguay.

ROUGH-LEGGED HAWKS

The rough-legged hawk, an arctic species circumpolar in distribution, differs from the other species of *Buteo* in that the tarsi are feathered all the way to the toes. Because of this character many authors have placed it in a separate genus (*Archibuteo* or *Triorchis*). At present it is more or less generally agreed that it is a *Buteo*. In addition to the three subspecies here listed there is a Kamchatkan race that possibly deserves recognition.

European Rough-legged Hawk. ***Buteo lagopus lagopus*** **(PONTOPPIDAN).**

Range: Northern regions of the Scandinavian countries and east to central Siberia.

The largest of the three forms. Plumage lighter and browner than that of the American subspecies; darker with much less white than in the Siberian race.

*** Siberian Rough-legged Hawk.** ***Buteo lagopus pallidus*** **(MENZBIER).**

Range: Arctic regions of northern Siberia from the Ob Valley to western Alaska (Friedmann, 1934).

Larger than the American form, and lighter in color. Feathers of upperparts broadly margined with white; streaks on throat and breast paler and narrower.

*** American Rough-legged Hawk.** ***Buteo lagopus s.-johannis*** **(GMELIN).**

Range: Arctic America from northern Alaska east to Newfoundland

Slightly smaller and, on the average, much darker than the typical form. There is much variation in color and some birds are nearly black.

FERRUGINOUS ROUGH-LEG

This is the largest of all the American buteos and is probably not equalled in size by any other species of the genus. It is strictly an American form and there are no closely related species. As in the preceding species the tarsi are feathered to the toes.

*** Ferruginous Rough-leg.** ***Buteo regalis*** **(GRAY).**

Range: Southern Washington, Alberta, and Manitoba, south to northern California, Nevada, Utah, and Colorado.

HARRIS'S HAWKS

*** Harris's Hawk.** ***Parabuteo unicinctus harrisi*** **(AUDUBON).**

Range: Southwestern United States from California to Texas, south to Panama and northern South America.

General coloration sooty brown; lesser wing coverts and thighs reddish brown.

One-banded Hawk. ***Parabuteo unicinctus unicinctus*** **(TEMMINCK).**

Range: South America from Venezuela and Surinam to central Argentina and central Chile.

Slightly smaller and more blackish brown than the preceding.

MEXICAN GOSHAWKS

Since this species resembles some of the small South American buteos and is in no way related to the true goshawks, the above common name is inappropriate.

There has been some controversy regarding the classification of the forms of the genus *Asturina*. Swann (1922) and Swann and Wetmore (1930) separate it into two species, *plagiata* and *nitida*. The former is divided into two forms and the latter into three. Peters (1931) includes all five in one species and uses the name *nitida* as it has priority over *plagiata*. This classification seems to be the most logical since the characters used to distinguish the two species are very slight.

*** Mexican Goshawk.** *Asturina nitida plagiata* SCHLEGEL.

Range: Southern Arizona and the lower Rio Grande Valley south to Guatemala.

Plumage above dark gray without bars; chest gray without bars; abdomen lightly banded.

Central American Goshawk. *Asturina nitida micrus* MILLER AND GRISCOM.

Range: Nicaragua, south on the Pacific slope to northwestern Costa Rica

Smaller and plumage paler than that of the Mexican goshawk.

Costa Rican Goshawk. *Asturina nitida costaricensis* SWANN.

Range: Southern and southwestern Costa Rica, south to Panama.

Similar in size but darker in color than the preceding. Lightly barred above and below.

Shining Goshawk. *Asturina nitida nitida* (LATHAM).

Range: Tropical South America from Panama to southern Brazil.

Slightly larger than the Central American form and barred above with silvery white; underparts banded with silvery white and slaty gray.

Bolivian Goshawk. *Asturina nitida pallida* TODD.

Range: Eastern Boliva.

Lighter than the typical form, with more bluish gray and the barring below narrower.

MEXICAN BLACK HAWKS

* **Mexican Black Hawk.** *Buteogallus anthracinus anthracinus* (LICHTENSTEIN).

Range Southern Arizona, New Mexico and Texas, south to northern South America

Plumage entirely black, excepting a narrow white line across the base and a broad white band across the middle of the tail.

Antillean Black Hawk. *Buteogallus anthracinus cancrivorus* (CLARK).

Range Lesser Antilles and adjacent coastal districts of Colombia and Venezuela

Plumage blacker and tail band narrower than that of the typical form.

GOLDEN EAGLES

The golden eagle is a wide ranging species which occurs in nearly all suitable localities in the arctic and temperate zones of the northern hemisphere but not in the tropics. It has never been recorded south of the equator. As in other species which occupy so large a range, there is considerable difference in the size and coloring of birds from various geographical areas. According to Swann and Wetmore (1931), the principal characters by which the different subspecies may be distinguished are size, color of tarsi, color of hind neck plumage, color of under wing coverts and under parts of the body, and the presence or absence of rufous tints.

* **American Golden Eagle.** *Aquila chrysaëtos canadensis* (LINNAEUS).

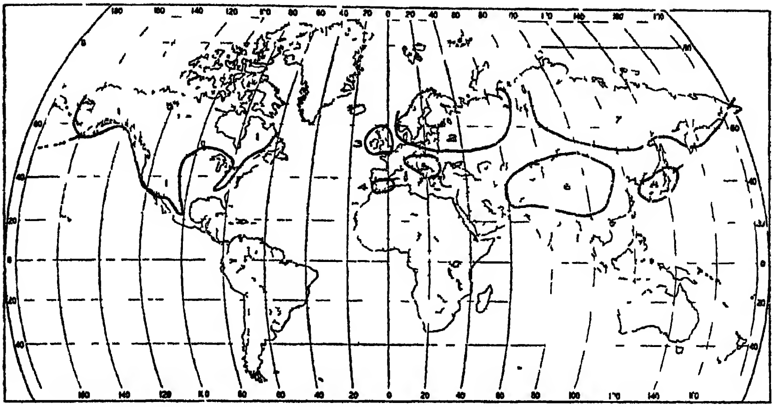
Range North America from northern Alaska east to Ungava, south to Lower California, central Mexico and, in the mountains of the eastern United States, to North Carolina and Tennessee.

The American bird is larger and very much darker than the typical form. The tarsi are dark brown, the upperparts and tibial plumes blackish bown, and the hind neck light brown.

Scandinavian Golden Eagle. *Aquila chrysaetos chrysaëtos* (LINNAEUS).

Range Scandinavian countries east to northern Russia and south through central Europe to the Carpathian Mountains

Comparatively small; plumage very pale; tarsi pale brown mottled with white; hind neck feathers pale tawny with light brown edges and pale tips; breast tawny.



DISTRIBUTION OF THE GOLDEN EAGLE

1—*Aquila chrysaetos canadensis*, 2—*A. c. chrysaetos*, 3—*A. c. fulvus*, 4—*A. c. homeyeri*, 5—*A. c. barthelemyi*, 6—*A. c. daphanea*, 7—*A. c. nobilis*, 8—*A. c. japonica*.

British Golden Eagle. *Aquila chrysaëtos fulva* (LINNAEUS).

Range: British Isles

Slightly larger and darker than the typical form. Tarsi light rufous brown; hind neck rufescent buff with dark brown centers: plumage below chocolate brown.

Spanish Golden Eagle. *Aquila chrysaëtos homeyeri* SEVERTZOV.

Range: Spain, Portugal, and the mountains of northern Africa

Similar in size to the preceding form. General color dark blackish brown without rufous tints; tarsi pale brown; feathers of hind neck light brown with buff tips.

Alpine Golden Eagle. *Aquila chrysaëtos berthelemyi* JAUBERT.

Range: The Alps of central Europe, southern Germany, upper Austria, and the Balkans.

A very large and dark form; deep umber brown above and below; tarsi brownish buff; feathers of hind neck brown with paler tips.

Himalayan Golden Eagle. *Aquila chrysaëtos daphanea* SEVERTZOV.

Range: Central Asia from Afghanistan and Baluchistan to eastern Assam and north to Transbaikalia.

Smaller than the preceding and much lighter than the typical form. Hind neck light tawny rufous; tarsi deep ferruginous with dark shaft lines, nearly black next to toes.

Siberian Golden Eagle. *Aquila chrysaëtos nobilis* PALLAS.

Range: Northern and eastern Siberia, south to the Himalayas, northern Mongolia and Kamchatka.

The largest of all forms. Plumage very dark blackish brown with no rufous below; tibial plumes very long; tarsi pale rufous buff, nearly white at bottom; hind neck rather dull buff.

This subspecies is not recognized by Peters (1931) who assigns two others to the range given above: *A. c. obscurior* Sushkin from the Russian Altai east to Transbaikalia and northern Mongolia, and *A. c. kamtschatica* Severtzov to Kamchatka.

Japanese Golden Eagle. *Aquila chrysaëtos japonica* SEVERTZOV

Range: Korea and Japan.

The smallest form. Similar to *A. c. daphanea* but smaller, darker, and with much lighter tarsi.

GRAY SEA EAGLES

* **Greenland Sea Eagle.** *Haliæetus albicilla groenlandicus* BREHM.

Range: Greenland.

Differs from the typical form in considerably larger size.

This subspecies is not recognized by Peters (1931) nor included in the A. O. U. Check-List (1931). Subspecific status is possibly more deserved in this case, however, than in that of the Alaskan bald eagle and several other accepted subspecies (Jourdain, 1933; Swann and Wetmore, 1934; and Jourdain in Bent, 1937, p. 316).

White-tailed Sea Eagle. *Haliæetus albicilla albicilla* (LINNAEUS).

Range: Iceland, formerly British Isles, the Scandinavian countries south to the Balkans and throughout central and eastern Europe, Asia Minor, northern and central Asia and Siberia east to Mongolia and Kamchatka.

BALD EAGLES

Although the bald eagle is found only in North America the genus comprises six or seven species that occur in other parts of the world and is closely related to the genus *Icthyophaga* of central Asia. All of these birds are rather sluggish in habits. They are normally found around larger bodies of water, their diet consisting largely of fish and carrion. As in many other groups there is a gradual decrease in size from the northern to the southern parts of the range and separation of the various forms is largely a matter of personal opinion.

*** Southern Bald Eagle.** *Haliæetus leucocephalus leucocephalus* (LINNAEUS).

Range: The southern half of the United States, south to Lower California and northern Mexico. Most common along the Atlantic and Gulf Coasts.

*** Northern Bald Eagle.** *Haliæetus leucocephalus alascanus* TOWNSEND.

Range: Northwestern Alaska east to northern Ungava and south to British Columbia, nothein Michigan and the northeastern United States.

The two forms differ only in size, the northern averaging much larger.

STELLER'S SEA EAGLE

*** Steller's Sea Eagle.** *Thallasoaëtus pelagicus* (PALLAS).

Range: Northeastern Siberia and Kamchatka. There are several records of its occurrence in western Alaska.

Peters (1931, p. 259) unites this genus with *Haliæetus.* It would seem to deserve generic rank, however, for the bird has a stronger bill which differs in shape and is much greater in height; also the tail has two more feathers.

MARSH HAWKS

The marsh hawks or harriers, as they are commonly called by Europeans, comprise a large group of species found in all parts of the world. There are two species in South America and two or three in most of the countries of Europe but only one race occurs in North America. All are similar in general appearance and habits.

*** Marsh Hawk.** *Circus cyancus hudsonius* (LINNAEUS.)

Range: North America from Lower California, Ohio and Virginia northward.

More brownish gray than the typical form; males have a few small rufous spots on the underparts.

Hen Harrier. *Circus cyaneus cyaneus* (LINNAEUS).

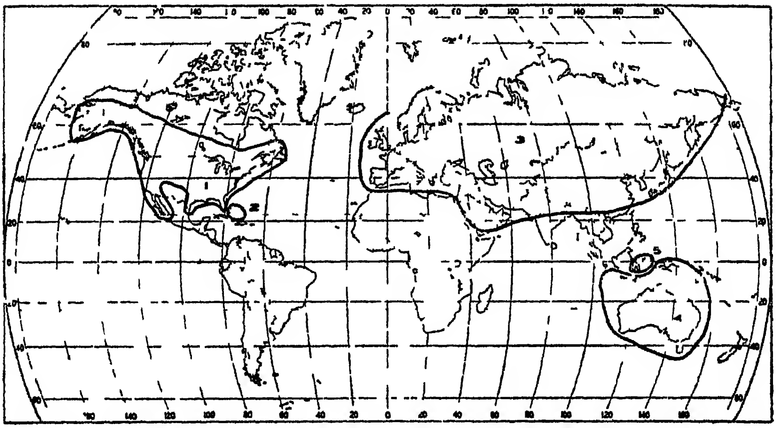
Range: Nearly all of Europe and western Siberia.

Males have no rufous spots on underparts.

Siberian Hen Harrier. *Circus cyaneus taissiae* BUTURLIN.

Range: Northeastern Siberia.

Both males and females are paler than those of the typical form.



DISTRIBUTION OF THE OSPREY

1—*Pandion haliaetus carolinensis*, 2—*P. h. ridgwayi*, 3—*P. h. haliaetus*, 4—*P. h. cristatus*, 5—*P. h. microhaliaetus.*

OSPREYS

The osprey or fish hawk is a widely distributed species occurring throughout most of the northern hemisphere as well as in the West Indies and Australia. The genus consists of a single species with five geographical races and may be distinguished from all other birds of prey by the rough, reticulate processes on the under sides of the toes, the reversible outer toe, and the particularly heavy and strong feet and claws. These are adaptations for grasping prey which consists entirely of fish.

* American Osprey. *Pandion haliætus carolinensis* (GMELIN).

Range: Northwestern Alaska to Newfoundland and south to Lower California and Florida.

Darker above; fewer marking below; the stripes on head blacker than in the typical form.

European Osprey. *Pandion haliætus haliætus* (LINNAEUS).

Range: Scandinavian countries east to Kamchatka and south to Spain, northern Africa, Arabia, and China.

Crown stripes browner; markings below more numerous than in the American form.

Bahaman Osprey. *Pandion haliætus ridgwayi* MAYNARD.

Range: Bahama Islands.

Head, hind neck and underparts pure white.

White-headed Osprey. *Pandion haliætus cristatus* (VIEILLOT).

Range: Australia, Tasmania, Java, the Moluccas, and New Guinea.

Similar above to the typical form, but head much whiter. Slightly smaller.

Lesser Osprey. *Pandion haliætus microhaliaëtus* BRASIL.

Range: New Caledonia and the Celebes.

Much smaller but otherwise similar to the Australian form.

CARACARAS

The caracaras represent a genus found only in the Americas. Only one race occurs in the United States but there are several species in South America. All are carrion eaters similar in habits; they resemble the vultures in many ways.

*** Audubon's Caracara.** *Polyborus cheriway auduboni* CASSIN.

Range: Southern United States and Cuba, south through Mexico to Panama.

Larger than the typical form; bill comparatively larger; plumage browner.

Cheriway Caracara. *Polyborus cheriway cheriway* (JACQUIN).

Range: Northwestern South America through Colombia, Ecuador and Venezuela to Surinam.

Much blacker than the American race.

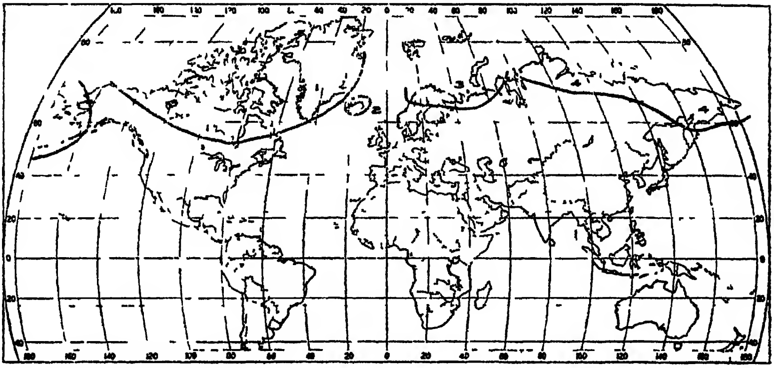
Tres Marias Caracara. *Polyborus cheriway pallidus* NELSON.

Range: Tres Marias Islands.

A pale insular form.

GYRFALCONS

Much has been written concerning the classification of the gyrfalcons but authorities have been unable to arrive at the same conclusions. The third edition of the A. O. U. Check-List (1910) recognized four American forms, one a separate species and the other three as races of



DISTRIBUTION OF THE GYRFALCON

1—*Falco r. obsoletus*, 2—*F. r. islandus*, 3—*F. r. rusticolus*, 4—*F. r. uralensis*.

another species. Swann (1922) recognized four forms of one species, three in North America and one of these a new race from Alaska. The fourth edition of the A. O. U. Check-List (1931) and Peters (1931) concurred in listing three American forms. The recent study by Wetmore (Swann and Wetmore, 1936), however, indicates that the birds formerly known as the white gyrfalcon (*F. r. candicans*) and the black gyrfalcon (*F. r. obsoletus*) are but color phases of the same subspecies and that there are consequently but two forms of the gyrfalcon in North America.

* **Greenland Gyrfalcon.** *Falco rusticolus obsoletus* GMELIN.

Range: Arctic zones from Greenland to northern Alaska.

This gyrfalcon has two color phases, one nearly white and the other brownish black. There are numerous intermediates in brownish gray plumage.

* **Asiatic Gyrfalcon.** *Falco rusticolus uralensis* (SEVERTZOV AND MENZBIER).

Range: Arctic zones from western Siberia east to Bering coast of Alaska, south to Kamchatka.

In this form the outer primary is equal to or shorter than the fourth, instead of longer as in the other races. The barring of the plumage is buffish white.

Scandinavian Gyrfalcon. *Falco rusticolus rusticolus* LINNAEUS.

Range: Northern Scandinavian countries, Lapland and northern Russia, east to western Siberia.

This race is always dark with no white phase. The plumage is barred with pale bluish gray.

Iceland Gyrfalcon. *Falco rusticolus islandus* BRÜNNICH.

Range: Iceland.

Slightly larger than *F. r. rusticolus;* plumage lighter, barred with grayish white.

PRAIRIE FALCON

* Prairie Falcon. *Falco mexicanus* SCHLEGEL.

Range: Western North America from southern British Columbia and southeastern Saskatchewan south to Lower California and northern Mexico.

There are no geographical races of this species although there are several closely related species in eastern Europe and India.

DUCK HAWKS

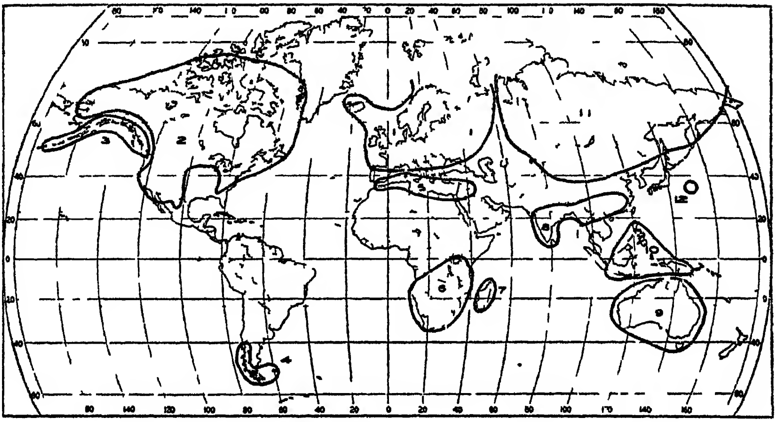
The duck hawk, or peregrine falcon as it is known in all countries except America, is the most widely distributed of any raptorial bird in the world. One or more forms occur on every continent and in nearly every country. As in other species of circumpolar distribution, the northern forms are larger and those of the southern and tropical regions are smaller and more richly colored. There is great variation in color and pronounced individuality of markings even among birds of the same region. Many geographical races have been described and few authorities agree on the status of several races in eastern Europe and central Asia.

Peters (1931) follows Hartert in considering the Barbary falcon (*F. peregrinoides*) a subspecies of the peregrine, but most other authorities regard its smaller size and differences in coloration as sufficiently definitive to give it specific status.

* Peregrine Falcon. *Falco peregrinus peregrinus* TUNSTALL.

Range: Casual in Greenland. Breeds in Iceland and throughout most of Europe south to southern Spain and the Balkans and east to western Siberia.

Upperparts bluish slate barred with blackish slate; underparts white with a faint pinkish buff tinge on sides of breast; throat and breast unspotted; chest with narrow black shaft stripes.



DISTRIBUTION OF THE PEREGRINE FALCON OR DUCK HAWK

1—*Falco peregrinus peregrinus*, 2—*F. p. anatum*, 3—*F p. pealei*, 4—*F p cassini*, 5—*F. p brookei*, 6—*F. p perconfusus*, 7—*F. p radama*, 8—*F. p. peregrinator*, 9—*F. p. macropus*, 10—*F p ernesti*, 11—*F p calidus*, 12—*F. p. fruitii*.

* Duck Hawk. *Falco peregrinus anatum* BONAPARTE.

Range: Nearly all of North America (excepting the Pacific Northwest) south to Lower California, central Mexico and South Carolina.

Slightly larger than the typical form. The black mustachial stripe is more extensive, the chest is more buffy and has fewer markings.

* Peale's Falcon. *Falco peregrinus pealei* RIDGWAY.

Range: The Pacific coast region from the Aleutian to the Queen Charlotte Islands.

Much darker than the duck hawk. Head, neck and shoulders almost black and the underparts heavily marked with slaty black.

Cassin's Falcon. *Falco peregrinus cassini* SHARPE.

Range: Western coast of South America from Chile to the Straits of Magellan and the Falkland Islands.

Smaller and paler than the duck hawk; back more gray with wider bars; underparts more densely and finely barred.

Mediterranean Peregrine. *Falco peregrinus brookei* SHARPE.

Range: Southern Spain, Islands of the Mediterranean and adjacent countries east to Asia Minor.

Smaller than the typical form; feet more slender; color more ruddy buff with underparts more finely spotted.

South African Peregrine. *Falco peregrinus perconfusus* COLLIN AND HARTERT.

Range: Africa from the Blue Nile and Angola south to Cape Colony.

The smallest of the species. More dull in color than the typical form; markings on abdomen closer together.

Madagascar Peregrine Falcon. *Falco peregrinus radama* HARTLAUB.

Range: Madagascar and Comoro Islands

Very similar to the South African race but with darker plumage and black markings on underparts.

Indian Peregrine Falcon. *Falco peregrinus peregrinator* SUNDEVALL.

Range: Indian Peninsula, Ceylon and south China.

Larger than the South African peregrine but smaller than the typical form. Darker above than the latter; throat paler; underparts tawny ferruginous.

Black-cheeked Falcon. *Falco peregrinus macropus* SWAINSON.

Range: Australia and Tasmania.

Similar to the Indian peregrine in size but darker in color. Head and nape deep black; remainder of upper parts bluish ashy barred with black; underparts buffy, closely and narrowly barred with black.

Ernest's Falcon. *Falco peregrinus ernesti* SHARPE.

Range: Philippine Islands, Borneo, Greater Sunda Islands, New Guinea, and adjacent regions

Similar in size to the Australian form but plumage darker; chest more rufous; under tail coverts and thighs barred with bluish gray instead of white.

Siberian Peregrine Falcon. *Falco peregrinus calidus* LATHAM.

Range: Northern Asia from western Siberia east to Kamchatka and south to eastern China.

Much larger and paler than the typical form. Much less black on cheeks and ear coverts; more white on sides of neck behind ear coverts; white below with fewer markings and no buffy tinge.

Volcano Islands Peregrine. *Falco peregrinus fruitii* MOMIYAMA.

Range: Volcano Islands, Bonin Islands and adjacent region.

Similar to Peale's falcon but blacker on head and tail; underparts more slaty gray.

The peregrines from the Commander Islands have been separated under the name *rudolfi* but this form has not been generally accepted.

APLOMADO FALCONS

* Aplomado Falcon. *Falco fusco-cærulescens septentrionalis* TODD.

Range: Arizona, New Mexico, and southern Texas, south through Mexico to Central America

Larger than the typical form. Bill larger, tail longer and upperparts more brownish slate.

Lesser Aplomado Falcon. *Falco fusco-cærulescens femoralis* TEMMINCK.

Range Tropical South America from Matto Grosso, Brazil, to Venezuela Possibly north to Central America.

Smaller and more brightly colored than the typical form. More bluish slate and less brown above; less white on tail, bars narrower

Southern Aplomado Falcon. *Falco fusco-cærulescens fusco-cærulescens* VIEILLOT.

Range South America from Paraguay, northern Argentina, and Chile southward

Smaller than the North American form.

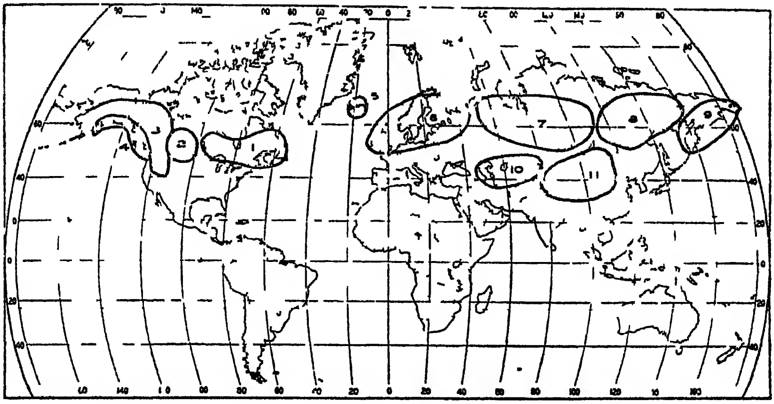
Andean Aplomado Falcon. *Falco fusco-cærulescens pichinchæ* CHAPMAN

Range The Andes of Ecuador and Peru

Differs from the preceding in larger size, darker upperparts, deeper buffy tints of breast, and smaller dark areas.

PIGEON HAWKS

The pigeon hawk may be considered a "small edition" of the duck hawk for it is similar to that species except in size and in selection of a nesting site. It either constructs its own nest in a tree or uses an old nest of some other bird, while the duck hawk makes no nest but deposits its eggs in some protected place on a rocky ledge. All authorities at present regard the European and Asiatic merlins and the pigeon hawk as geographical forms of the same species which, repre-



DISTRIBUTION OF THE MERLIN OR PIGEON HAWK

1—*Falco columbarius columbarius*, 2—*F. c. richardsonii*, 3—*F. c. bendirei*, 4—*F. c. suckleyi*, 5—*F. c. subaesalon*, 6—*F. c. aesalon*, 7—*F. c. regulus*, 8—*F. c. insignis*, 9—*F. c. pacificus*, 10—*F. c. christiani-ludovici*, 11—*F. c. lymani*.

sented by several different races, occupies an almost continuous range around the northern hemisphere.

From a zoogeographic point of view the distribution of the pigeon hawks is interesting in that a very light colored American race, *richardsonii*, occupies an area between the ranges of two dark forms, *columbarius* and *bendirei*, which are very similar to each other. There is a comparable situation in central Asia.

* Eastern Pigeon Hawk. *Falco columbarius columbarius* LINNAEUS.

Range Eastern and central Canada from the northern limit of trees south to southern Manitoba, northeastern Minnesota, northern Michigan, and northern Maine

The adult male is bluish slaty gray above with distinct black shaft lines on the feathers and with dark brown shaft streaks below. The female is dark umber brown above with wider and denser streaking below.

* Richardson's Pigeon Hawk. *Falco columbarius richardsonii* RIDGWAY

Range The plains region of central and southern Alberta and Saskatchewan south to northern Montana and North Dakota.

This form averages slightly larger than the preceding; the plumage is very much paler and more sandy brown. The male is pale bluish gray and brown above, striped with pale brown below, and the rufous

on the hind neck nearly forms a collar. The female is light brown and rufous above, instead of umber brown, and the markings below are light sandy brown.

Western Pigeon Hawk. *Falco columbarius bendirei* SWANN.

Range: Northwestern Alaska, Yukon and northwestern Mackenzie, south to British Columbia and, in the mountains, to northern California and Utah.

Differs very slightly from the eastern race but much darker than *richardsonii.* The male is slightly paler above than the eastern form; the female slightly more brown and less dark umber above.

Black Pigeon Hawk. *Falco columbarius suckleyi* RIDGWAY.

Range. Kodiak Island and coastal regions south to British Columbia and Vancouver Island

Slightly smaller and very much darker than typical form; bars on tail nearly obsolete. Male dark slaty black above, markings of underparts heavy and dark; female almost black above, markings below dense and very dark.

Iceland Merlin. *Falco columbarius subaesalon* BREHM.

Range: Iceland. Accidental in Greenland.

Similar to the merlin of western Europe but darker in both sexes. This and all other old world races differ from the typical form in having one or two more bands on the tail.

The European merlin (*Falco aesalon aesalon*) is listed in the A. O. U. Check-List (1931) as accidental in Greenland. Practically all recent authors, however, regard the old world merlins as subspecies of the pigeon hawk and it is the Iceland form (*subaesalon*) of this species which has been taken in Greenland.

Common Merlin. *Falco columbarius aesalon* TUNSTALL.

Range. British Isles, northern Europe, and the Scandinavian countries, east to the Minsk River and the Baltic States.

Both sexes much browner than the typical form; male slaty brown above.

Siberian Merlin. *Falco columbarius regulus* PALLAS.

Range: Northeastern Europe and western Siberia east through the Yenisei Valley, south to Moscow, Novgorod, Irkutsk, and northern Transbaikalia.

This race is supposed to be slightly lighter and more rufous than the preceding form (Peters, 1931). There is a difference of opinion,

however, as to the validity of the distinguishing characters and many authors do not separate *regulus* from *aesalon*.

Asiatic Merlin. *Falco columbarius insignis* (CLARK).

Range: Northern Siberia from the eastern range of *regulus* through Yakutsk to the Stanowi Mountains

Much paler than the common merlin; male lighter bluish gray with less brown above; female pale brown above, paler below with much less striping.

Kamchatkan Merlin. *Falco columbarius pacificus* (STEGMANN).

Range: Northeastern Siberia, Sakhalin and Kamchatka

Much darker than the preceding.

Pallid Merlin. *Falco columbarius christiani-ludovici* KLEINSCHMIDT.

Range: The Caucasus region and Kirghiz Steppes, north to Orenburg, Omsk and east to the Altai Mountains

Slightly larger and very much paler than *insignis*. Male pale gray above with pale rufous stripes below; female paler and more rufous.

Altai Merlin. *Falco columbarius lymani* BANGS.

Range: Tian-Shan Mountains, Mongolian Altai region east to the Changai range and north to southeastern Transbaikalia.

Similar to *insignis* but very much larger.

KESTRELS

The kestrel, a widely distributed and rather common Old World species which occurs in nearly all parts of Europe, Asia, and Africa, is included in the American list because of its accidental occurrence in Greenland and Massachusetts. It is closely related to the American sparrowhawk and like that species has been separated into many geographical races some of which are recognized by all authorities but others are questionable and their exact status still remains to be worked out.

* **Kestrel.** *Falco tinnunculus tinnunculus* LINNAEUS.

Range: All of Europe and western Asia, east to the Yenisei River and south to the Mediterranean and northern Persia.

The adult male differs from the female in having head, neck, lower back, rump, and tail bluish gray, the remaining plumage brighter

and more conspicuously marked. The female is entirely rufous above, more or less barred with black; below paler and streaked with rufous. Tail barred with black.

Siberian Kestrel. *Falco tinnunculus dörriesi* (SWANN).

Range: Northeastern Siberia from the Yenisei Valley to the Amur.

Larger and paler than the typical form; tail much longer. Female much more gray, with less brown and rufous.

Japanese Kestrel. *Falco tinnunculus japonensis* TICEHURST.

Range Japan and northeastern Asia through north China and Szechuan to Tibet, Ladak, and northern Kashmir.

Slightly larger and darker than the typical form, but lighter than the two following races.

Burmese Kestrel. *Falco tinnunculus saturatus* BLYTH.

Range: Yunnan, central and eastern Burma to Teneserim

Darker than any other race of this species. Many specimens have a decidedly smoky appearance.

Himalayan Kestrel. *Falco tinnunculus interstinctus* HORSFIELD.

Range: The mountains of the lower Himalayan region and northern India to Assam, Cachar, and Manipur.

Much darker and more heavily spotted and striped than the typical form. Lighter than the Burmese race, the male with less slaty gray above.

Wetmore (1936, p. 436) does not recognize *japonensis* and *saturatus* but combines them with *interstinctus*, although he states that the details of distribution remain to be worked out. Baker (1928, p. 64) recognizes the three but questions the distribution of the various Asiatic races.

Indian Kestrel. *Falco tinnunculus objurgatus* (BAKER).

Range: Central and southern India from Mysore to Travancore and Ceylon

Differs from the other Indian forms in that the plumage is richer, brighter, and more red; the underparts are very rufous.

Arabian Kestrel. *Falco tinnunculus buryi* GRANT AND MACKWORTH-PRAED.

Range: Southern Arabia from Aden Protectorate east to Dhufar.

More richly colored, especially below; thighs more rufous and crown more streaked than in typical form; lacks vinous tinge of *carlo*.

African Mountain Kestrel. *Falco tinnunculus carlo* (HARTERT AND NEUMANN).

Range: Highlands of northeastern Africa from Ethiopia and Somaliland to northern Tanganyika.

Smaller and darker than the typical form and similar to *interstinctus* but with less reddish brown. Head, upper tail coverts and tail in males dark slaty gray instead of blue gray as in the typical form. Much of the plumage has a vinous bloom.

Egyptian Kestrel. *Falco tinnunculus rupicolaeformis* (BREHM).

Range: Egypt and Nubia.

Plumage deep reddish brown, especially dark on underparts; markings heavy.

Canarian Kestrel. *Falco tinnunculus canariensis* (KOENIG).

Range: Madeira and the western Canary Islands.

Smaller and much darker than the typical race.

East Canarian Kestrel. *Falco tinnunculus dacotiae* HARTERT.

Range: Eastern Canary Islands (Fuertaventura and Lanzarote).

Larger than *canariensis* but smaller than the typical form; underparts deep rusty.

Cape Verde Kestrel. *Falco tinnunculus neglectus* SCHLEGEL.

Range: Cape Verde Islands.

A small, dark insular form similar to *canariensis* less reddish brown and with heavier markings. Slightly smaller than *carlo,* the gray on head of male more sandy.

South African Kestrel. *Falco tinnunculus rupicolus* DAUDIN.

Range: South Africa north to southern Angola and Nyasaland.

Plumage in general rich rufous red; differs from typical form in that male has sides of face dull blue-gray like top of head, and that tail of female is bluish gray instead of rufous.

Swainson's Kestrel. *Falco tinnunculus rufescens* SWAINSON.

Range: Senegal to the Cameroons and Belgian Congo.

Similar to *carlo* but darker. This supposed race and the two following are not very well understood and the details of distribution of each require additional study.

Archer's Kestrel. *Falco tinnunculus archeri* HARTERT AND NEUMANN.

Range: Lowlands of Somaliland, Socotra Island, and south along the coast to Lamu in Kenya Colony.

Smaller than the typical form; female paler. Doubtfully distinguishable from *carlo*.

Tanganyikan Kestrel. *Falco tinnunculus tanganyikae* GRANT AND MACKWORTH-PRAED.

Range: Tanganyika Territory

Described as smaller and darker than the typical form. Probably the same race as *carlo*.

AMERICAN SPARROW HAWKS

The sparrow hawk is the New World representative of the European kestrel which, although smaller, it resembles in habits and appearance. Some form occurs in nearly every part of North, Central, and South America as well as Cuba and the West Indies. There is much individual variation in color among birds of the same region and a difference in color of the young and old. These variations in addition to the migration of birds from one region to another have made classification difficult. The present arrangement is still far from satisfactory and the exact status and distribution of several forms remain to be determined.

During past years this species has been the subject of a good deal of controversy for the several authorities who have made comprehensive studies of the group have arrived at somewhat different conclusions. Some authors have seen fit to separate the sparrow hawks from the true falcons and place them with the kestrels in the genus *Cerchneis*. Cory (1915) under this genus recognized eleven South American races of one species exclusive of insular forms. Swann (1922) listed only fifteen forms for all the Americas but separated them into four different species. Peters (1931) under the genus *Cerchneis* lists twenty-three forms as one species (*sparverius*) but questions the status and range of three. The whole group probably represents a single species but the present status of some subspecies may be changed by additional research.

* **Eastern Sparrow Hawk.** *Falco sparverius sparverius* LINNAEUS.

Range: Upper Yukon, Mackenzie and Newfoundland south to northern California, Utah, Colorado, central Texas, northern Alabama, and north Carolina.

Back of male normally barred with black; usually a rufous crown patch; underparts light rufous, more or less barred.

DISTRIBUTION OF THE SPARROW HAWK

1—*Falco sparverius sparverius*, 2—*F. s. paulus*, 3—*F. s. phalaena*, 4—*F. s. peninsularis*, 5—*F. s. tropicalis*, 6—*F. s. sparveroides*, 7—*F. s. dominicensis*, 8—*F. s. loquaculus*, 9—*F. s. caribaerum*, 10—*F. s. brevipennis*, 11—*F. s. margaritensis*, 12—*F. s. isabellinus*, 13—*F. s. ochraceus*, 14—*F. s. intermedius*, 15—*F. s. caucae*, 16—*F. s. aequatorialis*, 17—*F. s. peruvianus*, 18—*F. s. distinctus*, 19—*F. s. eidos*, 20—*F. s. cinnamominus*, 21—*F. s. fernandensis*.

* **Little Sparrow Hawk.** *Falco sparverius paulus* (HOWE AND KING).

Range: Southern Mississippi east to South Carolina and south through Florida.

Smaller than *sparverius* but not as small as *peninsularis*. Male without spotting on underparts; breast light cinnamon fawn, fading nearly to white on lower abdomen. Female slightly deeper red above than in *sparverius*.

*** Desert Sparrow Hawk.** *Falco sparverius phalaena* (LESSON).

Range: Southern California, southern Nevada, Arizona, New Mexico, and western Texas, south to northern Lower California and northwestern Mexico.

Paler than *sparverius;* tail relatively longer; crown patch averaging larger. The difference between this and the typical form seems to be more constant in the female which is much lighter and more sandy rufous above, slightly lighter below.

*** San Lucan Sparrow Hawk.** *Falco sparverius peninsularis* MEARNS.

Range: Lower California.

Very much smaller and paler than *phalaena.*

Guatemalan Sparrow Hawk. *Falco sparverius tropicalis* (GRISCOM).

Range: Guatemala, exact limits unknown.

Slightly smaller and darker than typical form. Male has a very dark crown with distinct black shaft lines and black fringe at base of neck; little or no crown patch; heavily barred above; rather light below but heavily marked with large black spots and streaks. Female darker below and more blackish brown than typical form.

Cuban Sparrow Hawk. *Falco sparverius sparveroides* VIGORS.

Range: Cuba and the Isle of Pines.

This form is very unusual in that there are two color phases of the male. One is similar to *paulus* but with little or no crown patch; underparts lighter, lower abdomen pure white. The other phase is dark sooty gray above with more or less red; underparts deep rufous. The female is more reddish brown above, with the bars farther apart; apart; underparts lighter than in *paulus.*

Santo Domingan Sparrow Hawk. *Falco sparverius dominicensis* GMELIN.

Range: Santo Domingo and Haiti.

Male usually without crown patch; black bars on back very wide but few in number; breast pale fawn, unspotted, fading to white on abdomen. Female much richer brown than in the typical form; bars more distinct; below similar to the male but with a few more markings.

Puerto Rican Sparrow Hawk. *Falco sparverius loquaculus* (RILEY).

Range: Puerto Rico and adjacent Islands.

Somewhat similar to *caribaerum* but male not as heavily barred above, more cinnamon and less spotted below; tail with fewer markings. Female less heavily marked below.

Antillean Sparrow Hawk. *Falco sparverius caribæarum* GMELIN.

Range: Lesser Antilles.

Male dark above, heavily barred with black; chest washed with ochraceous fawn or light rufous; numerous large black spots on breast and sides; tail distinctly barred. Underparts of female very heavily streaked and spotted.

Curaçao Sparrow Hawk. *Falco sparverius brevipennis* (BERLEPSCH)

Range: Curaçao, Aruba, and Bonaire Islands.

Similar to *ochraceus* but male more heavily marked on back and with more spotting below. Female slightly darker and more streaked than *isabellinus*.

Margaritan Sparrow Hawk. *Falco sparverius margaritensis* (CORY).

Range: Margarita Island.

Similar to *isabellinus* but male with crown much darker, back lighter and underparts darker; female lighter.

Isabellan Sparrow Hawk. *Falco sparverius isabellinus* SWAINSON.

Range: Coastal districts of northern South America from Santa Marta, Colombia, to Cayenne.

Much smaller than typical form and with little or no crown patch; very light colored above with practically no black markings; very light and unspotted below. Female very light below but with a few streaks and spots of pale brown.

Venezuelan Sparrow Hawk. *Falco sparverius ochraceus* (CORY).

Range: Mountain regions of northeastern Colombia and western Venezuela.

A very distinctive race characterized by deeply colored and unspotted underparts and broad subterminal band on tail. Male similar to *dominicensis* but slightly darker above and below, deep color extending to under tail coverts.

Colombian Sparrow Hawk. *Falco sparverius intermedius* (CORY).

Range: Eastern slopes of the central Andes and the llanos of eastern Colombia east to Venezuela.

Very similar to *ochraceus* and doubtfully distinguishable but supposed to average slightly larger; subterminal tail band narrower; crown of male darker.

Caucan Sparrow Hawk. *Falco sparverius caucae* (CHAPMAN).

Range: Cauca Valley of western Colombia and the western slopes of the central Andes south to northwestern Ecuador.

Very similar to *peruvianus,* doubtfully distinguishable; supposed to differ in having paler underparts.

Andean Sparrow Hawk. *Falco sparverius aequatorialis* MEARNS.

Range: Subtropical and temperate zones of Ecuador.

This form is characterized by very dark underparts marked with blackish brown spots and streaks. Male similar to that of *ochraceus* but much darker above; much darker cinnamon below, spotted on sides. Female more reddish brown and darker.

Peruvian Sparrow Hawk. *Falco sparverius peruvianus* (CORY).

Range: Southwestern Ecuador and northern Peru south to Huanuco.

Differs from *cinnamominus* in that male is smaller, darker below, subterminal band of tail broader. Differs from *eidos* in being darker, tail much darker rufous; female similar, but tail richer brown and less conspicuously marked.

Amazonian Sparrow Hawk. *Falco sparverius distinctus* (CORY).

Range: Rio Branco region of northern Brazil and Amazonas Valley exact limits unknown.

Similar to *isabellinus* but paler above, especially on the head, and much lighter below; wings and tail average longer.

Brazilian Sparrow Hawk. *Falco sparverius eidos* PETERS.

Range: Eastern Peru, eastern Bolivia and Brazil, south of the Amazon, south to northern Paraguay and northeastern Argentina.

Smaller than the typical form; head more bluish gray, black shaft lines more distinct; more heavily spotted below. Differs from *cinnamominus* in smaller size, less spotted underparts, shorter tail, and broader subterminal tail band; female much smaller and lighter in color.

Cinnamon Sparrow Hawk. *Falco sparverius cinnamominus* SWAINSON.

Range: Chile, southern Bolivia and southern Paraguay south to the Straits of Magellan.

Similar to *eidos* but larger; tail much darker rufous with subterminal band narrower; underparts slightly darker.

Juan Fernandez Sparrow Hawk. ***Falco spaverius fernandensis*** **(CHAPMAN).**

Range: San Fernandez Islands.

A very large form with heavily marked underparts.

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BULLETIN

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RECORDS OF AMPHIBIANS AND REPTILES OF THE CHICAGO REGION, 1935-1938.

By Walter L. Necker

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RECORDS OF AMPHIBIANS AND REPTILES OF THE CHICAGO REGION, 1935-1938.

By Walter L. Necker

Much additional material has been accumulated since Karl P. Schmidt and I published our "Amphibians and Reptiles of the Chicago Region" (Bull. Chicago Acad. Sci., 5: 57-77, 1935), and a great increase of local interest makes an enumeration of that material desirable at this time. Not only have there been changes in the nomenclature of many forms, but the status of several species in this area has been better clarified; other problems and gaps have become obvious and should be placed before our increasing group of field workers.

Our first list recorded 1,749 specimens; this list more than doubles that number adding 1,877. Much of this increase is due to my friend Dr. Orlando Park, Professor of Zoology at Northwestern University, whose enthusiasm and zeal for natural history promises shortly to return that institution to its former place as a leader in zoological field studies that Robert Kennicott made for it as director of its museum almost a century ago. Dr. Park's classes in field zoology and ecology have brought together a large amount of material which has been incorporated in the collections of Northwestern University and the Academy, rather than being discarded and wasted as in many other colleges. These extensive series, as well as further concerted collecting by individual students, have built up in less than five years an invaluable collection of the fauna of the Chicago area—a fitting nucleus for a great future university museum.

For a geographical discussion of the Chicago region, another paper will follow defining the collecting localities, and logical boundaries for local faunistic studies. Suffice it to say that our worst needs, herpetologically, are extensive collections from Kane, Kendall, and Grundy Counties in Illinois, and especially Newton, Jasper, and Starke Counties, Indiana. Turtles, in series, are still the main desiderata as a group.

My thanks are due to Karl P. Schmidt and Orlando Park for the privilege of studying the collections under their care; to Chester V. Wickware for much of the clerical work involved; and to all those who are responsible for the collection of the specimens enumerated in the following list—individuals too numerous to mention even if limited to those whom it has been my pleasure to have as companions in the field.

As in the previous list, the letters preceding catalog numbers designate our three local collections:

A. Chicago Academy of Sciences
F. Field Museum of Natural History
N. Northwestern University Museum

The fifty-two species, now represented in the area fall in the following groups:

CAUDATA, Salamanders	10
SALIENTIA, Frogs and Toads	11
SAURIA, Lizards	3
SERPENTES, Snakes	17
TESTUDINATA, Turtles	11

ANNOTATED LIST OF SPECIES

AMPHIBIA

CAUDATA — SALAMANDERS

Necturus maculosus maculosus Rafinesque. Mud puppy.

ILLINOIS. COOK Co.: Wilmette, in Lake Michigan, N 261. MCHENRY Co.: McHenry, F 2083.

INDIANA. PORTER Co.: Chesterton, Coffee Creek, N 1602.

For the first time a clutch of eggs of the mud puppy has been found in the Chicago Area; these were found by Dr. Orlando Park and his class in Coffee Creek near Chesterton, Indiana on July 24. There were 141 eggs attached to the bottom of a wooden box submerged in about four inches of water. The eggs were taken into the laboratory and allowed to develop to various stages and preserved. Although the life history of the mud puppy is well known in some parts of its range, this is the first chapter to be recorded in this area.

Triturus viridescens louisianensis Wolterstorff. Newt.

ILLINOIS. LAKE Co: Highland Park, F 22902.

Ambystoma jeffersonianum Green. Jefferson's Salamander.

INDIANA LAPORTE Co.: Davis Woods, N 1707. PORTER Co.: Dune Acres, A 5756; Tremont, A 2065, 4316.

Ambystoma maculatum Shaw. Spotted Salamander.

ILLINOIS COOK Co: Chicago, A 322; Palos Park, F 11879. LAKE Co.: Deerfield, F 22251. WILL Co.: Crete, F 17602.

MICHIGAN. BERRIEN Co: Three Oaks, A 5686.

Ambystoma opacum Gravenhorst. Opaque Salamander.

INDIANA. LAPORTE Co.: Smith, Davis Forest, N 260, 1670-71. PORTER Co.: Wilson, A.

Entered in our previous list as unverified since only the specimen from Wilson was known, we can now definitely include the opaque salamander in our fauna since three specimens have been collected by Dr. Park's classes.

Ambystoma tigrinum tigrinum Green. Tiger Salamander.

ILLINOIS. COOK Co.: Chicago, N 730, F 23681; Glenview, N 1630; Palos Park, F 28441; Riverdale, F 8470. DUPAGE Co.: Naperville, F 26115. LAKE Co.: Fox Lake, N 1593; Waukegan, N 729. MCHENRY Co.: McHenry, F 30606-7.

INDIANA. LAKE Co.: Miller, N 82. PORTER Co.: Chesterton, Coffee Creek, N 1571; Ogden Dunes, N 1605.

WISCONSIN. KENOSHA Co.: New Munster, A 5463-4.

Hemidactylium scutatum Schlegel. Four-toed Salamander.

INDIANA. PORTER Co.: Dune Acres, Tamarack Bog, A 5520, 5689-90.

Previously known only from the DesPlaines River bottom lands, E. G. J. Falck has collected three specimens in Cowles' Bog.

Plethodon cinereus Green. Red-backed Salamander.

INDIANA. LAPORTE Co.: Otis, N 74, 75-80; Smith, N 1017-18, 1600, 1654, 1683, 1706, F 30553. PORTER Co.: Dune Acres, F 22829, 23477-78, 28256-7, 30837-9, A 5414-5433, 5539-52, 5757-5773.

Eurycea bislineata bislineata Green. Two-lined Salamander.

No additional specimens.

Siren lacertina Linnaeus. Siren.

No additional specimens

SALIENTIA — FROGS AND TOADS

Bufo americanus americanus Holbrook. American Toad.

ILLINOIS. COOK Co.: Evanston, Carle Woods, N 258-9; Morton Grove, N 333, 515; Wilmette, Harms Road, N 1064-5.

INDIANA. LAPORTE Co.: Smith, N 334-340, A 2660, 2785-2804, 4382-91, 4685-89. PORTER Co.: Chesterton, Coffee Creek, N 1567-68, A 2661.

WISCONSIN. WALWORTH Co.: Lake Geneva, A 5143-4, 5166.

Bufo fowleri Hinckley. Fowler's Toad.

ILLINOIS. KANKAKEE Co.: Pembroke Tp., A 2656, 4702-6, F 23539, 30414. LAKE Co.: Waukegan, N 1781, 1586-7.

INDIANA. LAKE Co.: Miller, N 127. PORTER Co.: Baileytown, Goose Lake, A 5713-5715; Dune Acres, A 2657-8, 2736-40, 5155-56, 5393-5413.

MICHIGAN. BERRIEN Co.: Lakeside, F 25231; Sawyer, N 1021-29; Three Oaks, A 5685.

A partial explanation of the reported migrations of toads along the lake shore seems to be their need of water. On June 26, in a walk

along the shore from Baileytown to Port Chester I counted about 200 toads to less than a mile in a ten foot strip in from the water's edge. They appeared quite suddenly *after* dusk, and at first seemed to be there for food, i.e. the drift-wood fauna, especially the very abundant spider *Arctosa littoralis;* only three out of fifty, however, had these spiders in their stomachs, the rest, all with full stomachs, had evidently fed elsewhere than near the beach.

Acris crepitans Baird. Cricket Frog.

ILLINOIS. COOK Co.: Chicago, F 498, 514; Deer Grove, N 673-683, 1058-9, 1878; DesPlaines, N 89; Evanston, N 253; Wolf Lake, F 29557-8. DUPAGE Co.: Naperville, F 22309-400. GRUNDY Co.: Pequot, F 30403-11. KANKAKEE Co.: Hopkins Park, A 4734-40; Pembroke Tp., N 689-702, A 4344-48. LAKE Co.: Beach, F 8299; Fox Lake, F 1872, 2099; Grass Lake, A 3644-46; Volo, N 91; Waukegan, F 2106; N 90, 686-88, 1592, 1829, 1830, 1832-53, 1855-60, A 5774-80. WILL Co.: Lockport, F 2091; Marley, F 5568, 6299; New Lenox, N 92-96.

INDIANA. LAKE Co.: Miller, A 4317-18. LAPORTE Co.: Smith, F 30563-4, A 5572-73, 5691, A 2811. PORTER Co.: Chesterton, F 29556, A 2655; Dune Acres, F 22828, A 5534-37, 5741-43.

MICHIGAN. BERRIEN Co.: Lakeside, F 25225-7.

WISCONSIN. KENOSHA Co.: Kenosha, N. 1870-72; New Munster, A 5462; Pleasant Prairie, N 1868-69.

Pseudacris triseriata Maximilian. Swamp Tree Frog.

ILLINOIS. COOK Co.: Chicago, F 2075, 5951, 19208, 22017; Deer Grove, N 672, 1060. KANKAKEE Co.: Hopkins Park, A 4707-23; Pembroke Tp., F 30413. LAKE Co.: Pistakee Lake, A 2821; Volo, N 63; Waukegan, N 1589-91, 1854, 1877.

INDIANA. LAPORTE Co.: Smith, N 790, 1016, 1601, 1709, F 30560-61, A 2812, 4681, 5578. PORTER Co.: Dune Acres, F 22860-62, 22501-03, 30610, 23476, A 5740.

Hyla crucifer Maximilian. Spring Peeper.

ILLINOIS. LAKE Co.: Deerfield, F 11979.

INDIANA. LAPORTE Co.: Smith, N 1014, 1603, 1676-82, 1864-67, F 30560, A 2810, 4679-80, 5574-77. PORTER Co.: Dune Acres, F 22827, 23504, 30611, A 5527-33, 5744-55.

Hyla versicolor versicolor LeConte. Common Tree Toad.

ILLINOIS. KANKAKEE Co.: Hopkins Park, A 4724-32; Pembroke Tp., F 30401-2. LAKE Co.: Fox Lake, N 1558.

INDIANA. LAPORTE Co.: Smith, A 2809. PORTER Co.: Chesterton, Coffee Creek, N 1557; Dune Acres, F 22826, 23475, 23498-500, A 5154, 5434-35, 5803-4, A 5538; Tremont, A 5716-17.

Rana cantabrigensis cantabrigensis Baird. Wood Frog.

ILLINOIS. COOK Co.: Carle Woods, N 250, 257, 1652-53; Wheeling, F 20659. LAKE Co.: Deerfield, F 11075-77

INDIANA. LAPORTE Co.: Smith, N 1019, 1604, 1606, 1675, 1861-63, 1873, F 30557, A 2805-07, 4682, 5567-70. PORTER Co.: Chesterton, Coffee Creek, N 1559-65; Dune Acres, F 28279, A 5525-26, 5736-37; Tremont, N 1690-92, A 928.

MICHIGAN. BERRIEN Co.: Lakeside, F 25228.

Rana catesbeiana Shaw. Bull Frog.

ILLINOIS. DUPAGE Co.: Naperville, F 22219, 23793. LAKE Co.: Waukegan, F 2105. MCHENRY Co.: McHenry, F 29433.

Rana clamitans Latreille. Green Frog, Cow Frog.

ILLINOIS. DUPAGE Co.: Naperville, F 22300, 23792. LAKE Co.: Grass Lake, A 3647-49; Waukegan, A 4313, N 731, 1588. WILL Co.: New Lenox, Hickory Creek, N 169; Romeo, F 23543.

INDIANA. LAPORTE Co.: Smith, F 30554-56, N 1708, 2808, 5167-68, A 5565-66. PORTER Co.: Chesterton, Coffee Creek, N 864, 1566; Dune Acres, F 23491, A 5738.

MICHIGAN. BERRIEN Co.: Lakeside, F 25229; Three Oaks, A 5684.

WISCONSIN. KENOSHA Co.: Camp Lake, N 1066-7. WALWORTH Co.: Lake Geneva, A 5145-47, 5167-68.

Rana palustris Le Conte. Pickerel Frog

WISCONSIN. WALWORTH Co.: Delavan, F 22414

Rana pipiens Schreber. Leopard Frog

ILLINOIS. COOK Co.: Chicago, F 28480; Deer Grove, N 121, 122-124, 684-685, 874, 1061-63, 1068-83, 1876; Evanston, Carle Woods, N 251-252; Palos Park, A 276, 2814; Willow Springs, N 97, 125-6. GRUNDY Co.: Coal City, F 25219-20, 25420; Pequot, F 30412. KANKAKEE Co.: Hopkins Park, A 4349-53; Pembroke Tp., A 4733. LAKE Co.: Deerfield, F 12993; Pistakee Lake, A 2815-20; Waukegan, N 1573-85, 1816, 1831, A 5681-83, 5781-86. MCHENRY Co.: McHenry, F 29424-7. WILL Co.: Romeo, A 5030.

INDIANA. LAKE Co.: Gary, A 5718; Miller, A 2812. LAPORTE Co.: Smith, A 4684, 5571. PORTER Co.: Chesterton, Coffee Creek, N 1551-56; Dune Acres, F 23492, 30880-81, A 5436, 5732-35. NEWTON Co.: Lake Tp., Sec. 3, F 25291.

MICHIGAN. BERRIEN Co.: Lakeside, F 25230.

WISCONSIN. WALWORTH Co.: Lake Geneva, A 5148-51; Richmond, F 28587.

REPTILIA

SAURIA — LIZARDS

Ophisaurus ventralis Linnaeus. Glass "Snake."

INDIANA. LAKE Co.: New Chicago, F 23474.

Cnemidophorus sexlineatus Linnaeus. Six-lined Swift.

ILLINOIS. KANKAKEE Co.: Hopkins Park, A 4701; Pembroke Tp., A 4314-15, F 23789-91.

INDIANA. LAKE Co: Miller, N 57, 150, 151-153, 263-284. PORTER Co.: Beverly Shores, F 19436-7; Ogden Dunes, N 30, 640; Tremont, F 30548-9; Wilson, N 28-29.

Eumeces fasciatus Linnaeus. Five-lined, Blue-tailed, or Red-headed skink.

No additional specimens.

SERPENTES — SNAKES

Heterodon contortrix Linnaeus. Hog-nosed Snake. Puff Adder.

INDIANA. PORTER Co.: Dune Acres, A 5075.
MICHIGAN. BERRIEN Co.: Bridgman, F 25296

Opheodrys vernalis Harlan. Grass Snake, Green Snake.

ILLINOIS. COOK Co.: Chicago, N 254, A 3643, 4319, 4819-17, F 1880, 22304, 28443-6, 30532; Evanston, N 167, 291, 710; Harvey, F 20706, 22856, 28293. DUPAGE Co.: Hinsdale, F 29378-86

Coluber constrictor flaviventris Say. Blue Racer.

INDIANA. LAPORTE Co.: Smith, N 1015. PORTER Co.: Dune Acres, F 22251, 22818-23, 22333-4, A 5521-24

Elaphe obsoleta obsoleta Say. Pilot Black-snake.

No additional specimens.

Elaphe vulpina Baird and Girard. Fox Snake, Spotted Adder.

ILLINOIS. COOK Co.: Bloom Tp., F 23545; Lemont, F 27275. GRUNDY Co.: Pequot, F 30419. KANKAKEE Co.: Aroma Pk, F 30542. LAKE Co.: Barrington, F 25295; Beach, N 513; Volo, Sayer Bog, N 5. WILL Co.: DuPage Tp., F 25223; Romeo, A 5033-34

INDIANA. PORTER Co.: Porter, F 22250.

Pituophis sayi sayi Schlegel. Bull Snake.

ILLINOIS. KANKAKEE Co.: Pembroke Tp., N 48, F 25402.

Lampropeltis triangulum triangulum Lacepéde. Milk Snake.

ILLINOIS. COOK Co.: Beverly Hills, F 3006; Chicago, F 30421; Glenview, N 38, 256. DUPAGE Co.: Naperville, F 25020, 26291, 29563. KANE Co.: Elburn, F 28611. LAKE Co.: Waukegan, F 25439-40, 25481-85. MCHENRY Co.: McHenry, F 29371. WILL Co.: Romeo, A 5031.

INDIANA. PORTER Co.: Dune Acres, F 22825; Valparaiso, N 166.

Natrix grahamii Baird and Girard. Graham's Water Snake.

ILLINOIS. COOK CO.: Chicago, A 5035, F 29565-82, 30422-28; Henry, F 29155; Summit, F 23231-3.

Natrix kirtlandii Kennicott. Kirtland's Water Snake.

ILLINOIS. COOK CO.: Chicago, A 3862; Palos Park, F 23166, 25293; River Forest, F 25436-7.

Natrix septemvittata Say. Queen Snake. Leather Snake.

ILLINOIS. COOK CO.: Lambert, F 3080-81, 23758-73, 23778, 27279-80. DUPAGE CO.: Naperville, F 17646. WILL CO.: Lemont, Sag Bridge, A 4566-68; New Lenox, A 2663, N 171; Romeo, A 4401

Natrix sipedon sipedon Linnaeus. Common Water Snake.

ILLINOIS. DUPAGE CO.: Naperville, F 22284. LAKE CO.: Waukegan, Dead River, N 516. WILL CO.: Hickory Creek, N 1, 119, 168; Wheatland Tp., F 26825.

INDIANA. PORTER CO.: Chesterton, Coffee Creek, N 50; Wilson, F 24142-47.

WISCONSIN. WALWORTH CO.: Lake Geneva, A 5078, 5153.

Storeria dekayi Holbrook. DeKay's Snake.

ILLINOIS. COOK CO.: Braeside, F 15699-703, 15761, 18052-60, 22831-36; Edgebrook, F 3527; Elmwood Park, A 5077; Homewood, F 22235, 22857; Lambert, F 27281; Lemont, F 27700. DUPAGE CO.: Naperville, F 22401. LAKE CO: Pistakee Lake, F 13198; Volo, Sayer Bog, N 31-32, 802.

INDIANA. PORTER CO.: Chesterton, Coffee Creek, N 716, 1594-95.

Storeria occipito-maculata Storer. Red-bellied Snake.

ILLINOIS. COOK CO.: Chicago, F 11271, 22831.

Thamnophis butleri Cope. Butler's Garter Snake.

No additional specimens.

Thamnophis radix Baird and Girard. Plains Garter Snake.

ILLINOIS. COOK CO.: Arlington Heights, N 173; Beverly Hills, F 19786; Blue Island, F 30420; Chicago, N 201, 202-207, 309-319, 346, 348-350, 772-780, A 1849, 4309, 4405, 4818-23, F 17035-39, 25004-5, 26020-30, 28260-80; Chicago Ridge, F 3058, 8289; Evanston, N 117, 299-300, 704-5, F 26293-6, 26298-301; Glenview, N 130, 131-133, 351, 354; Homewood, F 21747-54, 22858, 22864, 22903, 28294, 27276; LaGrange, F 25981; Lambert, F 27277; Pullman, F 1931; River Forest, F 25438; Wheeling, N 298; Wilmette, N 128, A 5040. DUPAGE CO.: Hinsdale, F 29132, 29134-6, 29138, 29154; Naperville, F 25979-80, 26303-5, 26031-2; West Chicago, A 2032-33; Wooddale, F 29419. GRUNDY CO.: Pequot, F 30417. LAKE CO.: Fox Lake, F 25404; Highland Park, F 26302; Winnetka, F 22596-635. MCHENRY CO.: Cary, N 208; Fox River Grove, F 29133, 29137; McHenry, F 29201-42, 29278-80, 29318-20, 29321-63, 29428-32. WILL CO.: New Lenox, A 4310.

WISCONSIN. KENOSHA CO.: New Munster, A 5453-61. WALWORTH CO: Lake Geneva, A 5079-80; Pell Lake, F 30552.

Thamnophis sauritus proximus Say. Ribbon Snake.

No additional specimens.

Thamnophis sirtalis sirtalis Linnaeus. Common Garter Snake.

ILLINOIS. COOK Co.: Chicago, A 4311, F 1929, 2434, 19207; Deer Grove, N 570, 671; Glenview, N 129, 352-3; Lambert, F 27278; Willow Springs, F 1922. GRUNDY Co.: Pequot, F 30416. LAKE Co.: Beach, F 1904; Fox Lake, F 1896a, F 25039; Pistakee Lake, F 25297; Volo, Sayer Bog, N 6; Waukegan, Dead River, N 163, 170; Waukonda, F 2726. McHENRY Co.: F 2073, 29423.

INDIANA. PORTER Co.: Chesterton, Coffee Creek, N 1597; Dune Acres, F 22824; Tremont, A 3641.

WISCONSIN. WALWORTH Co.: Delavan Lake, F 29250-69; Pell Lake, near Geneva, F 30431.

Sistrurus catenatus catenatus Rafinesque. Massasauga.

ILLINOIS. COOK Co.: Wheeling, N 595-6, F 26324. LAKE Co.: Deerfield, F 25960, A 5467.

INDIANA. LAPORTE Co: Smith, A 4012. PORTER Co.: Tremont, N 512, F 22346.

TESTUDINATA — TURTLES

Sternotherus odoratus Latreille. Musk Turtle. Stink-pot.

ILLINOIS. COOK Co.: Chicago River, N. Br., A 5817. DUPAGE Co.: Hinsdale, F 29387-8. McHENRY Co.: McHenry, F 29408-9.

INDIANA. LAKE Co.: Miller Lagoon, N 134-137, 377, 379, 420-2, 433-37, 462-69; Osborn, N 35.

WISCONSIN. WALWORTH Co.: East Troy, N 1425-6; Elkhorn, N 1143; Lake Como, nr. Lake Geneva, N 1547-1550.

Chelydra serpentina Linnaeus. Snapping Turtle.

ILLINOIS. COOK Co.: Carle Woods, N 1684; Harms Woods Creek, N 393; Riverview Park, Chicago, N 181. KANKAKEE Co.: Kankakee, F 22413. LAKE Co.: Lake Zurich, N 34; Waukegan Flats, N 391, A 4953. McHENRY Co.: Cary, N 875-6. WILL Co.: Hickory Creek, N 33, 138.

INDIANA. LAKE Co.: Miller Lagoon, N 180, 380. PORTER Co.: Chesterton, Coffee Creek, N 863.

Clemmys guttata Schneider. Spotted Turtle.

ILLINOIS. WILL Co.: Romeo, A 4402.

INDIANA. LAPORTE Co.: Smith, A 4692. PORTER Co.: Chesterton, Coffee Creek, N 1572; Dune Acres, A 4957, F 23680, 28251-54, 28300; N 1352; Woodville, N 49.

The first good Illinois record of this species was collected by my colleague Thurston I. Wright at Romeo, where two shells were also seen but not collected.

Emys blandingii Holbrook. Blanding's Turtle.

ILLINOIS. COOK Co.: Homewood, A 5074. KANKAKEE Co.: Pembroke Tp., N 365. LAKE Co.: Volo, Sayer Bog, N 149, 161; Waukegan Flats, A 4952, 5480. WILL Co.: Wheatland Tp., F 28499.

INDIANA. LAKE Co.: Gary, N 162. NEWTON Co.: Kentland, N 1667; PORTER Co: Dune Acres, N 1696, A 4956, F 23547; Ogden Dunes, F 28256.

WISCONSIN. WALWORTH Co.: Elkhorn, F 21690.

Terrapene carolina Linnaeus. Box Turtle.

INDIANA. LAPORTE Co.: Smith, N 145. PORTER Co.: Dune Acres, F 22237-8.

Terrapene ornata Agassiz. Ornate Box Turtle.

ILLINOIS. KANKAKEE Co.: Aroma Tp., F 30543; Pembroke Tp., A 4955, 4958-60, 5465, F 22239, 23540, 30415. WILL Co.: N. of Bonfield, Kankakee Co., F 26400.

Graptemys geographica LeSueur. Geographic Turtle.

No additional specimens.

Chrysemys picta marginata Agassiz. Painted Turtle.

ILLINOIS. COOK Co.: Evanston, Carle Woods, N 509; Highland Park, F 6760; Jackson Park, F 2674; River Forest, A 4488; Wolf Lake, F 11880. DUPAGE Co.: Naperville, F 18178, 22220. GRUNDY Co.: F 28606-7. KANKAKEE Co.: Pembroke Tp, N 366-7. LAKE Co.: Antioch, F 30430; Fox Lake, F 25038; Waukegan, Dead River, N 37, 113, 195, 332; Waukegan Flats, A 4954. McHENRY Co.: McHenry, F 29406-7. WILL Co.: Between Wilmington and Kankakee, F 30418.

INDIANA. LAKE Co: Hobart, N 192-3; Miller Lagoon, N 141-144, 194, 371-2, 374-376, 378, 381-83, 394-400, 401-419, 424-432, 438-461, 470-508. PORTER Co.: Chesterton, Coffee Creek, A 2664; Dune Acres, A 5076, F 23546; Ogden Dunes, F 28255.

WISCONSIN. KENOSHA Co.: Silver Lake, N 1695. WALWORTH Co: Elkhorn, Lake Pleasant, N 850-3, 865-870, 910-940, 1337-1424; Elkhorn, Lauderdale Lakes, N 877-888, 891-908: East Troy, Lake Buella, N 1281-1347; Lake Como, N 1428-1546; Lake Geneva, N 854; Lake Wandawega, 5 mi. N. of Elkhorn, N 941-1012.

Pseudemys troostii Holbrook. Cumberland Terrapin.

ILLINOIS. COOK Co.: Orland Park, N 361. KANKAKEE Co.: River nr. Altort Mills, N 1356.

INDIANA. LAKE Co.: Miller Lagoon, N 373.

Amyda spinifera LeSueur. Soft-shelled Turtle, Leatherback.

ILLINOIS. COOK Co.: Evanston, N 392. KANKAKEE Co.: Kankakee River, nr. Altort, N 1355

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BULLETIN

OF THE

CHICAGO ACADEMY OF SCIENCES

A NEW RATTLESNAKE FROM MEXICO

BY

HOWARD K. GLOYD
Chicago Academy of Sciences

AND

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Staten Island Zoological Society

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A NEW RATTLESNAKE FROM MEXICO

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In early June, 1933, the senior author received two live rattlesnakes from Willis Woolems, a reptile dealer in San Antonio, Texas, who had just returned from a collecting trip along the east coast of Mexico, south of Tampico, Veracruz. It was noted that these snakes were different in some respects from representatives of *Crotalus durissus durissus* then at hand but formal recognition by name was withheld pending the appearance of additional specimens. Both were photographed, the usual scale counts and other notes were recorded, the smaller was purchased and the larger returned to Mr. Woolems. A rattlesnake said to be from southern Chiapas recently received from Woolems by the Staten Island Zoological Society is similar in all fundamental characters to the two from Veracruz and furnishes additional data which seem to justify the description of a new form.

Although relationship with *durissus* is obvious, these specimens are apparently distinct in definitive characters and the geographic range of the population they represent is imperfectly known. For the present, therefore, the new form is not regarded as a subspecies of *durissus* but is given a binomial. Since we can not associate it definitely with any of the names already in the literature, we propose that it be known as

Crotalus totonacus, sp. nov.

Diagnosis.- Superficially similar to *C. d. durissus* but having a distinctly higher number of ventrals (male 189, 2 females 192, 194; maximum for *durissus* males 187, females 189), and relatively less subdivision of the scales of the head; a conspicuous spinal ridge is lacking, the scales of the body are less strongly tuberculate, and the paravertebral stripes are short and ill-defined.

Type Specimens.- Holotype: Chicago Academy of Sciences No. 4469 (Fig. 1), a subadult female from Panaco Island, about 75 miles south of Tampico, Veracruz, 12 miles inland from Cabo Rojo; collected in May, 1933. Paratype: an adult male, living in the collection of the Staten Island Zoological Society (Fig. 2), received in January, 1940, and said to have been collected in southern Chiapas.

Description of Type Specimens.- Holotype: Muzzle acute from above, obtusely truncate in profile. Rostral higher than wide, acutely rounded above, concave in front and below, slightly expanded at base. Internasals 2; canthals 2, in contact medianly; these 4 scales covering snout in front of supraoculars. Frontal region anteriorly covered by 2 large scales; these followed by 2 somewhat smaller scales which are in turn followed by a transverse row of 4, the outermost enlarged and curving backward and outward around the inner posterior borders of the supraoculars. Posterior edges of scales of muzzle and lateral edges of those of frontal region more or less recurved. Parietal region not distinct from temporal or occipital. Upper temporal and occipital scales moderately keeled.

Prenasals wider than postnasals, in direct contact with rostral except at lower anterior corners where there is a small scale between rostral, prenasal, and first supralabial. Loreals 3-3 (the upper divided). Four small scales on each side between nasals, labials, and pit. Preoculars 2-2, the lower forming upper posterior border of pit. Lacrimals 1-1. Postoculars 4-5. Orbit separated from supralabials by 3 scales on left side, 2 on right. Lower 3 rows of temporals without keels.

Fig 1 *Crotalus totonacus*, sp. nov., CA 4469 (Holotype), Panaco Island, near Cabo Rojo, 75 miles south of Tampico, Veracruz.

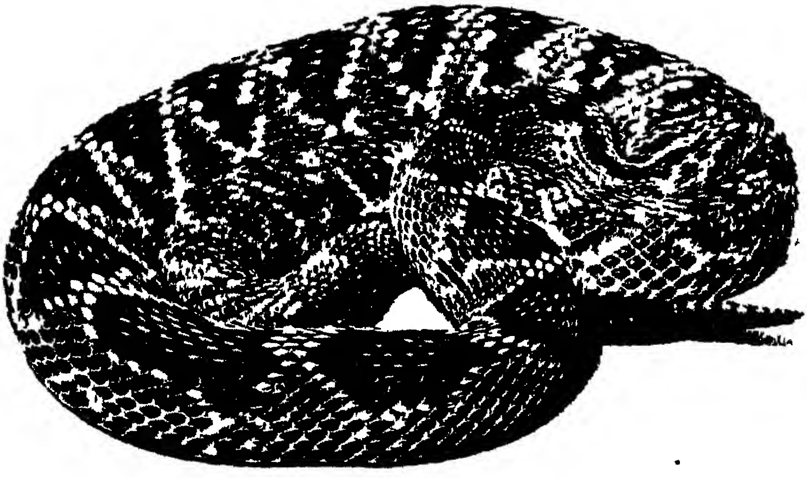

Fig. 2. *Crotalus totonacus*, sp. nov., Staten Island Zoological Society (Paratype), southern Chiapas.

Supralabials 15-14; infralabials 14-15, first pair not divided, meeting behind mental. One pair of chin shields, about twice as long as wide. Median gulars in 9 or 10 oblique rows between first ventral and last infralabial.

Dorsal scale rows 29-25-21, moderately keeled except 2 lowest rows on each side. Ventrals 192; caudals 24, the last divided. Anal not divided.

Total length when fresh 972 mm., tail 60 mm.; after six and one half years in alcohol 945 mm., tail 60 mm.; tail/total-length ratio .063. A complete set of 6 rattles, the largest (measured vertically) 13.3 mm., the smallest 4.7 mm.

Dorsal ground color yellowish olive, nearly all scales unicolor; sides and undersurfaces light yellow, belly with faint gray blotches, more numerous posteriorly. Pattern of head fairly distinct: internasals black-edged posteriorly; a narrow, transverse bar of black on posterior edges of canthals and anterior edges of supraocular and frontal scales; light supraocular dashes very wide, occupying nearly all of these plates. Cheek stripe obsolescent; no markings on rostral, sides of snout, or underside of head. A pair of irregular dark brown stripes beginning in parietal region and extending diagonally backward and outward to a point above and a little behind angle of jaw; between these a pair of parallel dark stripes extending from parietal area to neck and connecting with the first blotch of the body pattern, forming short, indistinct paravertebral stripes.

On the body a middorsal series of 31 brownish black blotches with centers of somewhat lighter brown and borders of light yellow, one scale wide; a single series of small brownish black spots on each side. Anteriorly the dorsal blotches are irregular diamonds, truncate in front, with slightly obtuse lateral angles; they are separated at the midline by one or two lengths of yellow scales. Posterior to midbody the rhombs become progresssively shorter, wider, and less distinct, and are joined to the lateral spots which likewise become fainter. Tail grayish black with 8 darker crossbands. Basal segment of rattle dark gray.

Paratype.-Essentially similar to the holotype but with the anterior frontal region occupied by one large plate which is followed by three small scales. Two enlarged scales posterior to the supraoculars mark the outer edges of the parietal region. Loreals 2-2; postoculars 4-4; scales separating orbit from supralabials 2-2. Supralabials 12-12; infralabials 13-13.

Scale rows 25-25-21; ventrals 189; caudals 27, the last and one near middle divided. Total length 1524 mm.; tail 120 mm.; tail/total-length ratio .079. Rattles 9+ (10), in an acuminate series.

The dorsal pattern of this specimen is well shown in Figure 2. The ground color ranges from "orange citrine" to "straw yellow"; the 26-28 blotches are black, bordered with "straw yellow" and with central patches of scales of the same tone as the ground color. The ventral surface is "straw yellow," immaculate.

The second specimen from Panaco Island (no longer at hand) was a large female, similar in nearly all respects to the two described above. Scale rows 25-25-20; ventrals 194; caudals 25; supralabials 13-13; infralabials 15-14; internasals 2; canthals 2; scales between supraoculars 2-2; loreals 2-2; scales separating orbit from supralabials 2-2; body blotches 30; tail bands (indistinct) 3-4; total length 1665 mm.; tail 110 mm.; tail/total-length ratio .066.

Range.- Known only from the type locality in Veracruz and questionably from southern Chiapas.

According to a recent letter from Mr. Woolems, the snake sent to the Staten Island Zoological Society was shipped to him from a point (not named) in southern Chiapas and was said to have been "just collected." If the locality given for this specimen is correct, the geographic distribution of this form is not what one would expect from a consideration of the topography of the region, and its range would appear to overlap that of *durissus*. On the other hand, if it is eventually shown that *totonacus* occupys the lowlands of the East Coast of southern Mexico, it may logically be regarded as a subspecies of *C. d. durissus*.

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BULLETIN

OF THE

CHICAGO ACADEMY OF SCIENCES

MAMMALS OF ILLINOIS

AN ANNOTATED CHECK LIST WITH KEYS AND BIBLIOGRAPHY

BY

WALTER L. NECKER

AND

DONALD M. HATFIELD

CHICAGO
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The Bulletin of the Chicago Academy of Sciences was initiated in 1883 and volumes 1 to 4 were published prior to June, 1913. During the following twenty-year period it was not issued. Volumes 1, 2, and 4 contain technical or semi-technical papers on various subjects in the natural sciences. Volume 3 contains museum reports, descriptions of museum exhibits, and announcements.

Publication of the *Bulletin* was resumed in 1934 with volume 5 in the present format. It is now regarded as an outlet for short to moderate-sized original papers on natural history, in its broad sense, by members of the museum staff, members of the Academy, and for papers by other authors which are based in considerable part upon the collections of the Academy. It is edited by the Director of the Museum with the assistance of a committee from the Board of Scientific Governors. The separate numbers are issued at irregular intervals and distributed to libraries and scientific organizations, and to specialists with whom the Academy maintains exchanges. A reserve is set aside for future need as exchanges and the remainder of the edition offered for sale at a nominal price. When a sufficient number of pages have been printed to form a volume of convenient size, a title page, table of contents, and index are supplied to libraries and institutions which receive the entire series.

Howard K. Gloyd, Director of the Museum

Committee on Publications:

Alfred Emerson, Professor of Zoology, University of Chicago.
John Rice Ball, Professor of Geology, Northwestern University.
Hanford Tiffany, Professor of Botany, Northwestern University.

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AN ANNOTATED CHECK LIST WITH KEYS AND BIBLIOGRAPHY

WALTER L. NECKER AND DONALD M. HATFIELD*

CONTENTS

Thirty years have elapsed since the last list of the mammals of Illinois was published. Since that time there have been numerous additional specimens collected and many changes in the nomenclature of these animals. Now that an active interest in the natural history of the state is again being developed, we feel that it is an opportune time to record the present extent of our knowledge of this fauna, primarily to point out the many gaps and problems confronting mammalogy in Illinois. With a view to helping and encouraging prospective students we have included a key to the species, a key to the skulls of genera, an annotated list of species, and a bibliography of mammals of the state. Included with the keys are figures to illustrate some of the less commonly used terms. The list of species is annotated with references to original

* Interested in a comparison of the distribution of reptiles and of mammals in the state, Mr. Necker some years ago began to compile geographic data on the mammals of Illinois. In addition to making a survey of the literature, he examined specimens from the state in the collections of several museums as well as those in the collection of the Academy. The data thus assembled are thought likely to be sufficiently helpful to students of the natural history of Illinois to warrant publication. In the hope of increasing the potential usefulness of this paper, Dr. Hatfield has prepared keys for the identification of the species and of the skulls of the genera; he has also examined pertinent museum material, assisted in the preparation of the manuscript, and supervised the preparation of the drawings which are the work of Oswald Boll of the Museum Extension Aid Project (No. 30185) of the Work Projects Administration.---*Ed.*

descriptions and to more extensive articles on the natural history of the animal, known locality records, and in some instances problems of particular interest and importance.

The work is by no means to be considered finished; it is hoped that this paper may furnish a basis for more intensive investigation. It is doubtful, in fact, whether we may ever expect to have a complete knowledge of the mammals of any area. The reasons for this are several. In the first place, animals undergo changes in distribution through extension or contraction of range. These changes may be due to either of two principal influences: changes of habitat resulting from "natural" or from human causes; and changes originating within the animal itself. It is because if these continual changes that it would be practically impossible to cover the state regularly and thoroughly enough to present a completely accurate current picture of the status of the mammals. Check lists are rarely more than reports of progress.

In addition to reviewing the available literature, we have examined specimens from the following institutions which contain the bulk of the Illinois material: U. S. Bureau of Biological Survey (now the Section of Biological Surveys); Chicago Academy of Sciences; Field Museum of Natural History; Museum of Zoology, University of Michigan; Northwestern University; and the United States National Museum. In addition, we have learned by correspondence of specimens in the following collections: Illinois State Natural History Survey, Urbana; Museum of Natural and Social Sciences, Southern Illinois Normal University, Carbondale; and the University of Illinois, Urbana.

We wish to express our appreciation to the following curators who allowed us to examine specimens in their care: Dr. Remington Kellogg and H. Harold Shamel of the U. S. National Museum; Dr. Hartley H. T. Jackson of the Biological Survey; Dr. W. H. Burt of the University of Michigan; Colin Campbell Sanborn of the Field Museum of Natural History; and Dr. Orlando Park of Northwestern University. We wish also to thank Tappan Gregory, Honorary Curator of Mammals of the Chicago Academy of Sciences, for permission to examine material in his private collection.

Our especial thanks go to Dr. C. O. Mohr, of the Illinois State Natural History Survey, Fred R. Cagle, of Southern Illinois Normal University, and E. J. Koestner, of the University of Illinois. Each of these informed us by letter of the specimens in collections at his institution. Mr. Koestner, who inaugurated a study of the mammals of Illinois several years ago, has been kind enough to allow us to include the bulk of his accumulated information here. To him we are indebted not

only for records from the collection of the University of Illinois, but also from his private collection, from that of Jane C. Dirks of the University of Illinois, from the collection of R. Magoon Barnes, Lacon, Illinois, from the Museum of Vertebrate Zoology, University of California (*vide* E. R. Hall), and from the Academy of Natural Sciences of Philadelphia (*vide* F. A. Ulmer).

HISTORICAL SUMMARY

The first important work on mammals of Illinois was that of Kennicott, published as several papers in the Patent Office Reports (1856-8). Fifty years later, Cory's *Mammals of Illinois and Wisconsin* was published, but is now out-of-date. At present, the most useful descriptive work on mammals of this general area is Lyon's *Mammals of Indiana.* Among local lists, Wood's *Mammals of Champaign County* and Gregory's *Mammals of the Chicago Region* stand virtually alone. In addition to the above works, there are numerous papers in which menton is made of specimens from Illinois; these are listed in the bibliography, which is probably far from complete, but does, we hope, list the more important contributions.

During the middle of the last century, the pioneer collectors of mammals, as well as of most natural history objects in Illinois, were Robert Kennicott and Friedrich Brendel. Their field work, although by no means restricted, centered mainly around their homes in West Northfield and Peoria, respectively. After an interval of nearly fifty years, during which only casual collecting was done, Edmund Heller gathered numerous specimens in the southern tip of the state, and Robert Ridgway sent many specimens, primarily from Richland County, to the National Museum. After another interval, the present generation of collectors became active; among the more prominent of these are: E. V. Komarek, J. J. Mooney, C. C. Sanborn, and D. A. Spencer. None of these excepting Sanborn is still actively collecting in the state, although there is probably a considerable amount of cursory collecting of which we have no record.

KEYS

The elusive manner and the nocturnal habit of most of our common mammals has in large part been responsible for the general lack of knowledge regarding them. In studying their habits and general biology, a primary step is the accurate recognition of the species concerned. To aid in this identification the following keys are presented.

The general key to species has been constructed primarily for use with fresh mammals in hand, although it may also be applied to study skins if skulls are available at the same time. Reference either to the figures or to the glossary at the end of the keys should explain or define terms not familiar. Methods of measuring mammals are indicated in Figure 1.

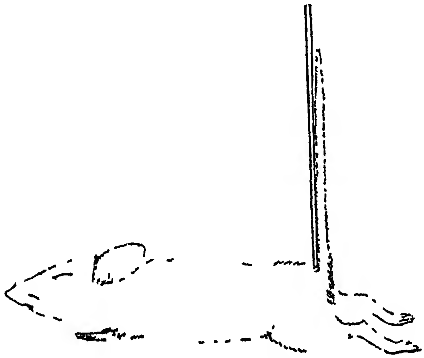
The key to skulls of genera is included principally for the identification of skulls picked up at random out-of-doors, or of skulls found in connection with the food remains of various predatory species; in other words, for the identification of skulls for which no skin or other part of the animal is available. Although the accompanying figure of a skull with the important parts labelled is of the carnivore type (Fig. 2), the terms apply equally well to rodent or other similar types.

In referring to the number of teeth of a mammal, it is customary to count those on one side only. Thus if, as under *7* in the skull key, the statement is made that there is one premolar above, we mean that there is one premolar on the upper jaw *on each side*. Also, the dental formula, or dentition, of a mammal refers only to the teeth occurring on one side of the upper and lower jaws. A dentition of $\frac{3\text{-}1\text{-}4\text{-}2}{3\text{-}1\text{-}4\text{-}3}$ indicates the presence of 3 incisors above and 3 below, one canine above and one below, 4 premolars above and 4 below, and 2 molars above and *3* below. The total number of teeth is, of course, twice this number, or in this instance 42. The formula is always written in this order, from the front to the back.

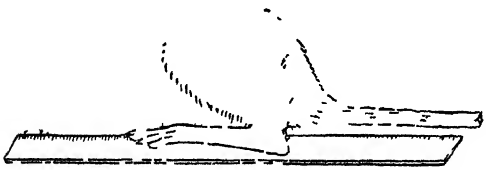
We wish to call particular attention to the part the carnassials play in the recognition of the teeth in the Carnivora. Here the fourth premolar above (Pm^4) and the first molar below (M_1) always form the carnassials. If on the upper jaw of some carnivore such as the cat, there are but two premolars between the canine and the carnassial, it means that the first premolar has been lost in the evolutionary development of the animal, and that only premolars 2, *3* and 4 remain. It is generally true that premolars are lost from the front and molars are lost from the back.

To illustrate the use of the keys, let us assume that we have a chipmunk in hand. Starting in the general key to species with point number *1*, we find that it does not fit here, so we proceed to *1a*, under which it could be placed. Then to *2*, but the front legs are not modified to serve as wings, so we go to *2a*, which states that all mammals under it do not have the forelimbs modified to serve as wings. Then to *13*, which is immediately under *2a*. Here we find the terms *canine teeth* and *incisor*. Referring to Figure 2, showing the parts of the skull, we find that canine teeth are long tearing teeth, which are absent in our specimen;

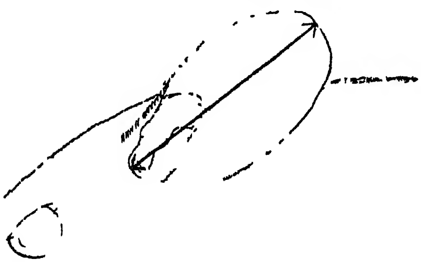
TOTAL LENGTH
from tip of nose to last tail vertebra.



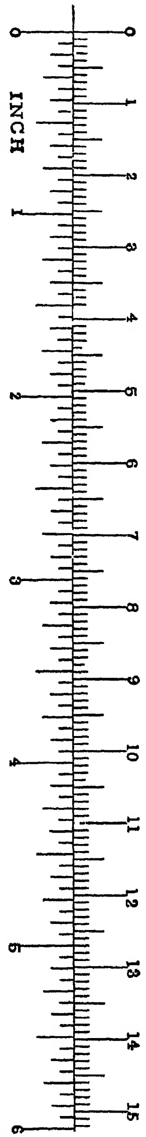
LENGTH OF TAIL
from sacrum to last tail vertebra.



LENGTH OF HIND FOOT
from heel to tip of longest claw.



LENGTH OF EAR
from notch to tip.



Metric and English systems compared.

Fig. 1. Methods of measuring mammals.

also, there is only one incisor on the lower jaw, so we proceed to *13a*. Following this same plan of choosing one of two alternatives, we arrive at point number *37*, where we find "Back longitudinally striped." It is. Then, under *38*, "Cheek teeth 4/4; back with 2 light stripes bordered with black.—*Tamias striatus* (Eastern Chipmunk)."

GENERAL KEY TO SPECIES

1. First toe of hind foot thumb-like and clawless; tail naked, scaly, and prehensile; teeth 50; total length of adults averaging 700 mm.—*Didelphis virginiana* (Virginia Opossum).

1a. First toe of hind foot never thumb-like; tail variable but not prehensile; teeth fewer than 50.

  2. Forelimbs modified to serve as wings.

    3. Dorsal surface of interfemoral membrane furred at least on basal half (from base of tail, half way to tip).

      4. Underside of wing furred to wrist; base of thumb furred.

        5. Total length more than 120 mm.; general color grizzled brown.—*Lasiurus cinereus* (Hoary Bat).

        5a. Total length less than 120 mm.; general color ranging from bright rufous to yellowish-gray. —*Lasiurus borealis* (Red Bat).

      4a. Underside of wing not furred to wrist; base of thumb not furred; general color blackish-chocolate, often with silvery tips on many of hairs.—*Lasionycteris noctivagans* (Silver-haired Bat).

    3a. Dorsal surface of interfemoral membrane naked except for scattered hairs, or furred only at extreme base.

      6. Ears relatively very long (around 30 mm.) and leaf-like.—*Corynorhinus rafinesquii* (Big-eared Bat).

      6a. Ears shorter, usually less than 20 mm. long.

        7. Fur same color at base as at tips.—*Myotis grisescens* (Gray Bat).

        7a. Fur darker at base than at tips.

          8. Total length usually more than 105 mm.; forearm more than 40 mm. long in adults.—*Eptesicus fuscus* (Big Brown Bat).

          8a. Total length less than 105 mm.; forearm less than 40 mm. long.

9. Ears extending conspicuously (3 to 4 mm.) beyond tip of nose when laid forward.—*Myotis keenii septentrionalis* (Big-eared Little Brown Bat).

9a. Ears not extending beyond tip of nose when laid forward.

10. One incisor above on each side.—*Nycticeius humeralis* (Rafinesque's Bat).

10a. Two incisors above on each side.

11. Forearm less than 36 mm. long; general color of back mottled yellowish-brown.—*Pipistrellus subflavus* (Georgian Bat).

11a. Forearm more than 36 mm. long; general color dull brown to coppery-brown.

12. Each hair of back banded in three zones (lower two-thirds slate-gray, followed by narrow band of light gray and finally a brown tip); foot slender, usually less than 8.5 mm. long; first toe less than 5 mm. long.—*Myotis sodalis* (Indiana Bat).

12a. Each hair of back banded in two zones; foot robust, usually more than 8.5 mm. long; first toe more than 5 mm. long.—*Myotis lucifugus* (Little Brown Bat).

2a. Forelimbs not modified to serve as wings.

13. Canine teeth present above; more than one incisor below.

14. Eyes and external ears but little developed; tail scantily haired; snout elongated and pointed; canine but little differentiated; carnassial not differentiated.

15. Forefoot nearly as broad as long; claws of forefoot compressed dorsoventrally.

16. Nostrils surrounded by a fringe of finger-like tentacles.—*Condylura cristata* (Star-nosed Mole).

16a. Nostrils not surrounded by a fringe of finger-like tentacles.—*Scalopus aquaticus* (Common Mole).

15a. Forefoot longer than broad; claws of forefoot compressed laterally.

17. Tail about one-fourth length of head and body.

18. Total length less than 100 mm.; hind foot less than 11 mm.; coloration brownish-gray.—*Cryptotis parva* (Least Shrew).

18a. Total length more than 100 mm.; hind foot more than 11 mm.; coloration slate-grayish.—*Blarina brevicauda* (Short-tailed Shrew).

17a. Tail at least one-half length of head and body.

19. Total length less than 85 mm.; three unicuspid teeth visible when skull is viewed from side.—*Microsorex hoyi* (Pigmy Shrew).

19a. Total length usually more than 85 mm.; at least four unicuspid teeth visible when skull is viewed from side.

20. Coloration reddish; third unicuspid smaller than fourth.—*Sorex longirostris* (Bachman's Shrew).

20a. Coloration brownish; third unicuspid not smaller than fourth.—*Sorex cinereus* (Cinereous Shrew).

14a. Eyes and external ears well-developed; tail well-haired; snout not greatly elongated; canine differentiated, long and prominent.

21. Hind foot with four claws.

22. Claws retractile; form cat-like.—*Lynx rufus* (Bobcat).

22a. Claws not retractile; form dog-like.

23. General color of upperparts gray; feet gray or tawny dorsally.

24. Pupil of eye round; hind foot more than 160 mm. long; skull more than 175 mm. long.—*Canis latrans* (Coyote).

24a. Pupil of eye elliptical; hind foot less than 160 mm. long; skull less than 175 mm. long.—*Urocyon cinereoargenteus* (Gray Fox).

23a. General color of upperparts reddish; feet black dorsally.—*Vulpes fulva* (Red Fox).

21a. Hind foot with five claws.

25. Entire sole of hind foot applied to ground in walking; carnassial but little developed; anal scent glands absent; tail fur annulated.—*Procyon lotor* (Raccoon).

25a. Entire sole of hind foot not applied to ground in walking; carnassial strongly developed; anal scent glands present.

26. Tail less than twice as long as hind foot.
 27. Total length less than 500 mm.; form slender.—*Mustela rixosa* (Least Weasel).
 27a. Total length more than 500 mm.; form robust, squat; claws on forefeet very large.—*Taxidea taxus* (Badger).
26a. Tail more than twice as long as hind foot.
 28. Color black and white; underparts black.—*Mephitis mephitis* (Skunk).*
 28a. Color not black and white; underparts not black.
  29. Conspicuous black tail-tip present; general body color tawny; total length less than 500 mm.—*Mustela frenata* (Long-tailed Weasel).
  29a. No conspicuous black tail-tip present; general body color dark chestnut brown; total length more than 500 mm.—*Mustela vison* (Mink).

13a. No canine teeth present; diastema between molariform and incisor teeth; incisors large and chisel-shaped, never more than one below.
 30. Hind legs greatly elongated, with tail shorter than hind foot; upper incisors 2, second one small and placed directly behind the first.
  31. Total length of adults more than 500 mm.; ear, from notch, more than 60 mm. long; tail thinly haired.—*Sylvilagus aquaticus* (Swamp Rabbit).
  31a. Total length of adults less than 500 mm.; ear, from notch, less than 60 mm. long; tail thickly haired.—*Sylvilagus floridanus* (Cottontail Rabbit).
 30a. Hind legs long or short--if long, with tail longer than hind foot; one incisor above.
  32. External cheek pouches present; claws on front feet much larger than those on rear feet; total length about 200 mm.—*Geomys bursarius* (Pocket Gopher).
  32a. External cheek pouches absent; claws on front feet about same size as those on rear feet.
   33. Tail broad (80 to 100 mm. wide), flat, scaly.—*Castor canadensis* (Beaver).
   33a. Tail not broad and flat, but variable.
    34. More than three cheek teeth on each side of lower jaw; tail bushy.

*Specimens of skunks from Illinois had best be submitted to an experienced worker for positive identification; the status of the forms to be found in this area needs further clarification.

35. Fore and hind limbs connected by a loose fold of skin; fur brownish-gray and very soft; nocturnal, volant, arboreal.—*Glaucomys volans* (Flying Squirrel).

35a. Fore and hind limbs not connected by a loose fold of skin.

36. Tail less than 30 per cent of total length; body robust, squat.—*Marmota monax* (Woodchuck, Groundhog).

36a. Tail more than 30 per cent of total length.

37. Back longitudinally striped.

38. Cheek teeth 4/4; back with 2 light stripes bordered with black.—*Tamias striatus* (Chipmunk).

38a. Cheek teeth 5/4; back with 6 light continuous stripes.—*Citellus tridecemlineatus* (Thirteen-lined Ground Squirrel).

37a. Back not longitudinally striped.

39. Total length less than 400 mm.

40. Top of tail always markedly reddish; pronounced line of demarcation between color of back and color of belly.—*Tamiasciurus hudsonicus* (Red Squirrel).

40a. Top of tail never markedly reddish; no pronounced line of demarcation between color of back and color of belly.—*Citellus franklinii* (Franklin's Ground Squirrel).

39a. Total length more than 400 mm.

41. Rufous below; cheek teeth 4/4.—*Sciurus niger* (Fox Squirrel).

41a. Grayish-white below; cheek teeth 5/4.—*Sciurus carolinensis* (Gray Squirrel).

34a. Three cheek teeth in lower jaw; tail not bushy.

42. Hind legs long and kangaroo-like; tail much longer than head and body; underparts buffy.—*Zapus hudsonius* (Jumping Mouse).

42a. Hind legs not long and kangaroo-like.

43. Tail less than three times as long as hind foot.

44. Upper incisors grooved on front surface.—*Synaptomys cooperi* (Lemming Mouse).

44a. Upper incisors not grooved on front surface.

45. Tail less than 25 mm. long.—*Pitymys pinetorum* (Pine Mouse).
45a. Tail more than 25 mm. long.
46. Five plantar tubercles; tail sharply bi-colored, dark above and light below.—*Microtus ochrogaster* (Prairie Meadow Mouse).
46a. Six plantar tubercles; tail not sharply bi-colored.—*Microtus pennsylvanicus* (Eastern Meadow Mouse).
43a. Tail more than three times as long as hind foot.
47. Tail scaly and laterally compressed (rudder-shaped); toes of hind feet fringed with stiff bristles.—*Ondatra zibethicus* (Muskrat).
47a. Tail not laterally compressed; toes of hind feet not fringed with bristles.
48. Upper cheek teeth with tubercles arranged in three longitudinal rows.
49. Hind foot less than 22 mm. long.—*Mus musculus* (House Mouse).
49a. Hind foot more than 22 mm. long.
50. Head and body longer than tail; upperparts brown; underparts grayish.—*Rattus norvegicus* (Norway Rat).
50a. Head and body shorter than tail; upperparts blackish; underparts yellowish-white.—*Rattus rattus* (Black Rat).
48a. Upper cheek teeth with tubercles arranged in two longitudinal rows or with prismatic triangles on cutting surface.
51. Upper cheek teeth long-crowned, with prismatic triangles; total length more than 300 mm.—*Neotoma floridana* (Wood Rat).
51a. Upper cheek teeth with tubercles; total length less than 300 mm.
52. Total length more than 225 mm.; tail more than 100 mm. long; pelage hispid.—*Oryzomys palustris* (Rice Rat).
52a. Total length less than 225 mm.; tail less than 100 mm. long.
53. Tail less than 70 mm. long, sharply bi-colored, dark above and light below; with dorsal blackish band evident.—*Peromyscus maniculatus* (Prairie White-footed Mouse).
53a. Tail almost always more than 70 mm. long, not sharply bi-colored.

54. Color golden brown; ears same color as pelage of back.—*Peromyscus nuttalli* (Southern Golden Mouse).

54a. Color brown or grayish-brown (not golden brown); ears usually darker than pelage of back, often edged with white.

55. Ear less than 15 mm. long from notch to tip.—*Peromyscus leucopus* (Woodland White-footed Mouse).

55a. Ear more than 15 mm. long from notch to tip.—*Peromyscus gossypinus* (Cotton Mouse).

Guide to Figure 2

al - alisphenoid
am - angle of mandible
bo - basioccipital
bsp - basisphenoid
c - canine
ca - carnassials (Pm ^{4} and M_1)
cm - condyle of mandible
cp - coronoid process
eam - external auditory meatus
eo - exoccipital
f - frontal
fm - foramen magnum
i - incisors
inc - incisive foramina
inf - infraorbital foramen
ip - interparietal
j - jugal
l - lacrimal
mp - mastoid process
mx - maxillary
m^1 - first upper molar
m_1 - first lower molar
n - nasal
oc - occipital condyle
or - orbit
pa - parietal
pl - palatine
pm^1 - first upper premolar
pm_1 - first lower premolar
pmx - premaxillary
pop - postorbital process
pp - paroccipital process
psp - presphenoid
pt - pterygoid
r - rostrum
sg - sagittal crest
so - supraoccipital
sq - squamosal
tb - tympanic or auditory bulla
v - vomer
zma - zygomatic arch

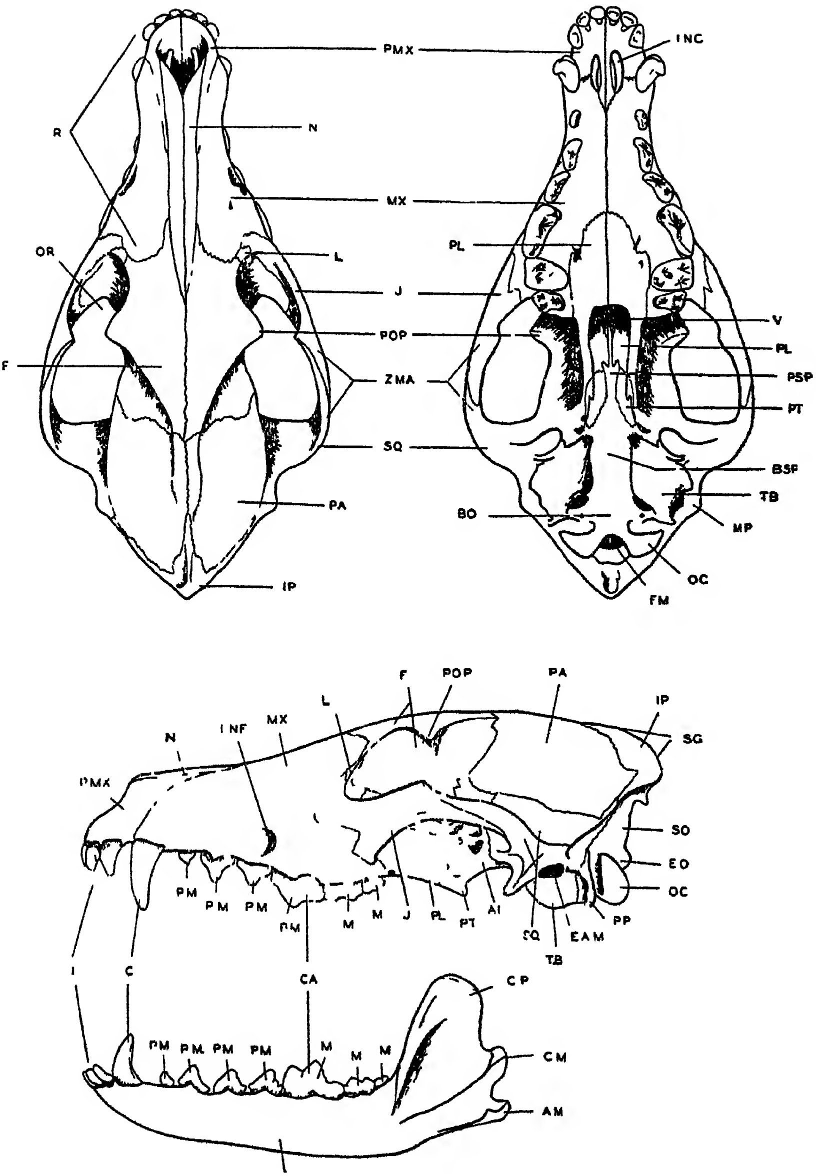


Fig. 2. Parts of a mammal skull.

KEY TO SKULLS OF GENERA

1. Canines present above and usually below (on upper and lower jaws); no large diastema between incisors and premolars.
   2. Pm^4 and M_1 not differentiated as carnassials.

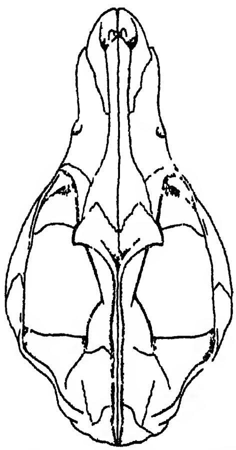


Fig. 3. Top view of skull of *Didelphis*. Note small braincase, a primitive character. (x 1/2).

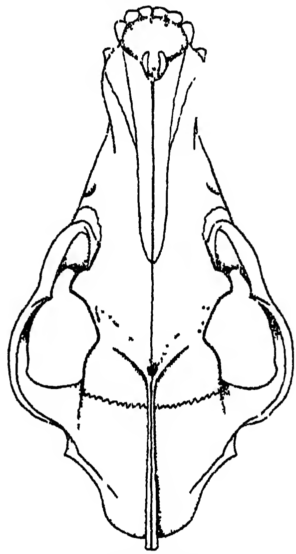


Fig. 4. Top view of skull of *Canis*. Note size of braincase; compare with Fig. 3. (x 1/3).

3. Braincase notably small (see Figs. 3 and 4); teeth 50 in number, dentition $\frac{5\text{-}1\text{-}3\text{-}4}{4\text{-}1\text{-}3\text{-}4}$.—DIDELPHIIDAE, *Didelphis* (see Fig. 9).

3a. Teeth fewer than 50.

4. Skull less than 50 mm. long.

5. Premaxillae not in contact with each other anteriorly (see Fig. 5).—VESPERTILIONIDAE. (Last three teeth above are molars; count as premolars those between canines and molars).

6. Cheek teeth (premolars and molars) 6/6, dentition $\frac{2\text{-}1\text{-}3\text{-}3}{3\text{-}1\text{-}3\text{-}3}$.—*Myotis*.

6a. Cheek teeth fewer than 6/6.

7. One premolar above.

8. Two incisors above, dentition $\frac{2\text{-}1\text{-}1\text{-}3}{3\text{-}1\text{-}2\text{-}3}$.—*Eptesicus*.

8a. One incisor above, dentition $\frac{1\text{-}1\text{-}1\text{-}3}{3\text{-}1\text{-}2\text{-}3}$.—*Nycticeius*.

7a. Two premolars above.

9. One incisor above, dentition $\frac{1-1-2-3}{3-1-2-3}$.—*Lasiurus.*

9a. Two incisors above.

10. Two premolars below, dentition $\frac{2-1-2-3}{3-1-2-3}$.—*Pipistrellus.*

10a. Three premolars below.

11. Width across canines five or more mm.; rostrum nearly as large as braincase when viewed from above; skull flat-topped; dentition $\frac{2-1-2-3}{3-1-3-3}$.—*Lasionycteris* (see Fig. 11).

11a. Width across canines less than five mm.; rostrum about one-half as large as braincase when viewed from above; skull arched, round-topped; dentition $\frac{2-1-2-3}{3-1-3-3}$.—*Corynorhinus.*

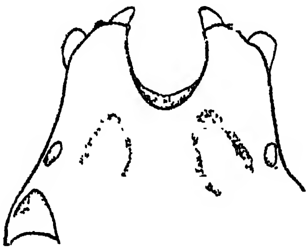


Fig. 5. Top view of rostrum of bat. Note premaxillae are not in contact anteriorly--there is a marked gap between them. (x 5).

5a. Premaxillae in contact with each other anteriorly.

12. Length of skull more than 30 mm.—TALPIDAE.

13. Mastoid breadth more than 45 per cent of skull length; second and third incisors small, not canine-like; dentition $\frac{3-1-3-3}{2-0-3-3}$.—*Scalopus* (see Fig. 10).

13a. Mastoid breadth less than 45 per cent of skull length; second incisor minute, third relatively large and canine-like; dentition $\frac{3-1-4-3}{3-1-4-3}$.—*Condylura.*

12a. Length of skull less than 30 mm.—SORICIDAE.

14. Dentition $\frac{3-1-2-3}{1-1-1-3}$; first upper premolar minute, usually not brown-tipped.—*Cryptotis.*

14a. Dentition $\frac{3-1-3-3}{1-1-1-3}$.

15. Greatest width across tooth rows more than 7 mm.; mastoid breadth more than 11 mm.; greatest length of skull averaging 23 to 25 mm.—*Blarina.*

15a. Greatest width across tooth rows less than 7 mm.; mastoid breadth less than 11 mm.; greatest length of skull less than 20 mm.

16. Skull, when viewed from side, with 5 unicuspid teeth (immediately following first, bifurcate, incisor); maxillary tooth row more than 5 mm. long.—*Sorex* (see Fig. 6).

16a. Skull, when viewed from side, with 3 unicuspid teeth (immediately following first, bifurcate, incisor); maxillary tooth row less than 5 mm. long.—*Microsorex* (see Fig. 7).

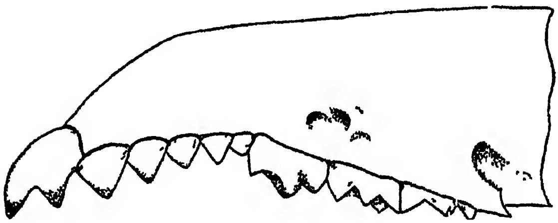


Fig. 6. Rostrum of *Sorex*, showing five unicuspid teeth. (x

Fig. 7. Rostrum of *Microsorex*, showing three unicuspid teeth. (x 8).

4a. Skull more than 50 mm. long (averaging 100-125 mm.); canines large; dentition $\frac{3\text{-}1\text{-}4\text{-}2}{3\text{-}1\text{-}4\text{-}2}$.—PROCYONIDAE, *Procyon.*

2a. Pm^4 and M_1 differentiated as carnassials.

17. Fewer than 3 molars below.

18. Postorbital processes strongly developed; rostrum short; braincase rounded and truncate; one lower molar.—FELIDAE.

19. Premolars 2/2.—*Lynx.*

19a. Premolars 3/2.—*Felis.*

18a. Postorbital processes weakly developed; rostrum short, but braincase long; two lower molars.—MUSTELIDAE.

20. Posterior border of hard palate extending appreciably beyond posterior edges of last upper molars.

21. Greatest length more than 90 mm.; upper carnassial with two medial cusps; dentition $\frac{3\text{-}1\text{-}3\text{-}1}{3\text{-}1\text{-}3\text{-}2}$.—*Taxidea.*

21a. Greatest length less than 90 mm.; upper carnassial with one medial cusp; dentition $\frac{3\text{-}1\text{-}3\text{-}1}{3\text{-}1\text{-}3\text{-}2}$.—*Mustela.*

20a. Posterior border of hard palate not extending appreciably beyond posterior edges of last upper molars; dentition $\frac{3\text{-}1\text{-}3\text{-}1}{3\text{-}1\text{-}3\text{-}2}$.—*Mephitis.*

17a. Three molars below.—CANIDAE.

22. Temporal ridges prominent, beaded, U-shaped; Pm^2 approximately twice as long as wide; dentition $\frac{3\text{-}1\text{-}4\text{-}2}{3\text{-}1\text{-}4\text{-}3}$.—*Urocyon.*

22a. Temporal ridges less prominent, not beaded, V-shaped; Pm^2 approximately three times as long as wide; dentition $\frac{3\text{-}1\text{-}4\text{-}2}{3\text{-}1\text{-}4\text{-}3}$.

23. Greatest length about 150 mm.—*Vulpes.*

23a. Greatest length 200 mm. or more.—*Canis* (see Fig. 12).

1a. Canines absent above and below; diastema between incisors and molariform cheek teeth; one incisor in each of lower rami.

24. Incisors 2/1; cheek teeth 6/5.—LEPORIDAE, *Sylvilagus* (see Fig. 14).

24a. Incisors 1/1.

25. Cheek teeth 3/3.

26. Upper cheek teeth with tubercles on grinding surface arranged in three longitudinal rows.—MURIDAE.

27. Greatest length more than 30 mm.; heavy ridges over orbit and posteriorly on skull.—*Rattus.*

27a. Greatest length less than 30 mm.; no heavy ridges on skull.—*Mus.*

26a. Upper cheek teeth with tubercles arranged in but two longitudinal rows, or with prismatic loops or triangles on cutting surface.—CRICETIDAE.

28. Upper cheek teeth with tubercles in two longitudinal rows.
    29. Greatest length 30 mm. or more; temporal ridges forming pronounced bead on sides of skull above orbits.—*Oryzomys*.
    29a. Greatest length less than 30 mm.; temporal ridges not beaded.—*Peromyscus*.
28a. Upper cheek teeth without tubercles, but with loops or triangles of enamel surrounding lakes of dentine.
    30. Upper incisors grooved longitudinally on front surface.—*Synaptomys*.
    30a. Upper incisors not grooved.

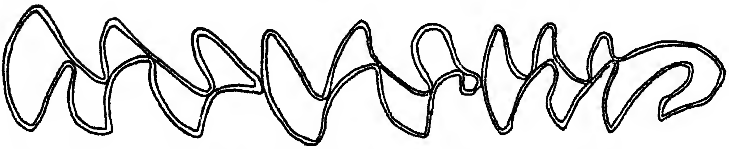


Fig. 8. Cutting surface of tooth row of *Microtus*. Note prismatic loops of enamel. (x 15).

31. Second upper molar with five loops.—*Microtus* (see Fig. 8).
31a. Second upper molar with fewer than five loops.
    32. Second upper molar with three loops; greatest length approximately 45 mm.—*Neotoma*.
    32a. Second upper molar with four loops.
        33. Skull more than 50 mm. in length.—*Ondatra*.
        33a. Skull less than 50 mm. in length.—*Pitymys*.

25a. Cheek teeth more than 3/3.
    34. Upper incisors grooved longitudinally on front surface.

35. Cheek teeth 4/3.—ZAPODIDAE, *Zapus.*

35a. Cheek teeth 4/4.—GEOMYIDAE, *Geomys.*

34a. Upper incisors not grooved.

36. Cheek teeth 4/4.

37. Cheek teeth long-crowned, growing from persistent pulp; skull more than 90 mm. long.—CASTORIDAE, *Castor* (see Fig. 13).

37a. Cheek teeth not long-crowned; skull less than 90 mm. long.—SCIURIDAE.

38. Greatest length of skull more than 55 mm.; length of upper cheek tooth row more than 10 mm.—*Sciurus.*

38a. Greatest length less than 55 mm.; length of upper cheek tooth row less than 10 mm.

39. Greatest length more than 45 mm.; rostrum about 10 mm. high at incisive foramina; upper cheek tooth rows about 7 mm. long.—*Tamiasciurus.*

39a. Greatest length less than 45 mm.; rostrum about 7 mm. high at incisive foramina; upper cheek tooth rows about 6 mm. long.—*Tamias.*

36a. Cheek teeth 5/4.

40. Postorbital processes extending more than 10 mm. out from skull.—*Marmota.*

40a. Postorbital processes extending less than 10 mm. out from skull.

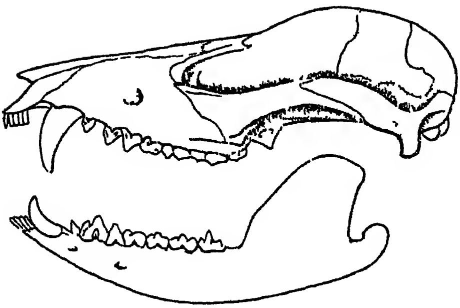
41. Notch in zygomatic plate of maxillary opposite third cheek tooth above.

42. Greatest length of skull more than 50 mm.; postero-medial edge of nasals more anterior than postero-lateral edge.—*Sciurus.*

42a. Greatest length of skull less than 50 mm.; postero-lateral edge of nasals usually more anterior than postero-medial edge.—*Citellus.*

41a. Notch in zygomatic plate of maxillary opposite second cheek tooth above.—*Glaucomys.*

TYPES OF SKULLS OF MAMMALS



Note the large number of teeth, but little differentiated. The opossum is omnivorous, i. e., it will eat almost anything; it has no need for specialized dentition. Note also the high sagittal crest, for muscle attachment, and the relatively small braincase (see also Fig. 3).

Fig. 9. A marsupial, *Didelphis* (x ½)

Here the large number of teeth indicates "primitiveness" while their structure might be taken to indicate advanced specialization; note the sharp points. Note also the low rounded braincase, a character accompanying fossorial habit, and the long slender rostium.

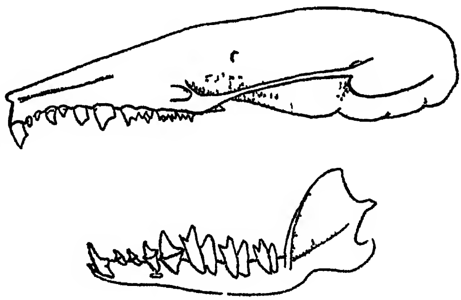
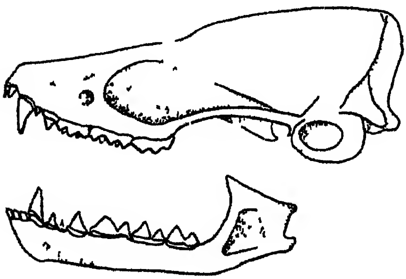
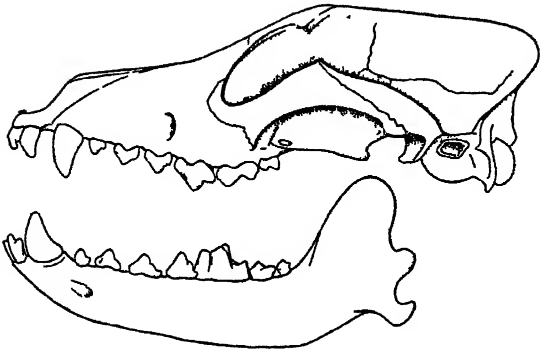


Fig. 10. An insectivore, *Scalopus* (x 1 ½)



Bats may be regarded as flying insectivores, hence the similarity in tooth structure between the bats and the moles (compare with Fig. 10). The sharp-pointed teeth are efficient in the mastication of insects, while the shortness of the rostrum is of aid in capturing insects on the fly.

Fig. 11. A bat, *Lasionycteris* (x 3 ½)



Note here the large carnassials (fourth premolar above and first molar below); these teeth come together with a shearing action comparable to that of a pair of scissors, and are useful in cutting through tendons and bone. The large canine teeth are adapted to a tearing or slashing action.

Fig. 12. A carnivore, *Canis* (x 1/3)

The large, chisel-shaped incisors are characteristic of all rodents or gnawers. Enamel occurs only on the front surface of these teeth, hence the backs wear more rapidly and a sharp edge is assured. Canines are absent and the cheek teeth are grinders. In all rodents, the lower jaw moves not only up and down but also backward and forward.

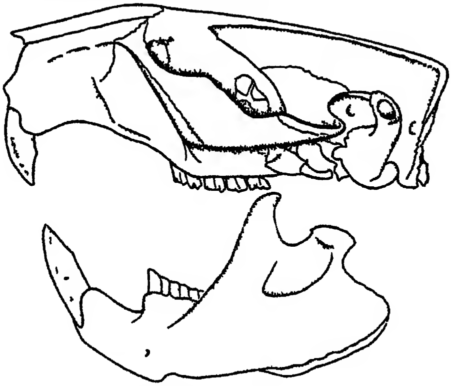
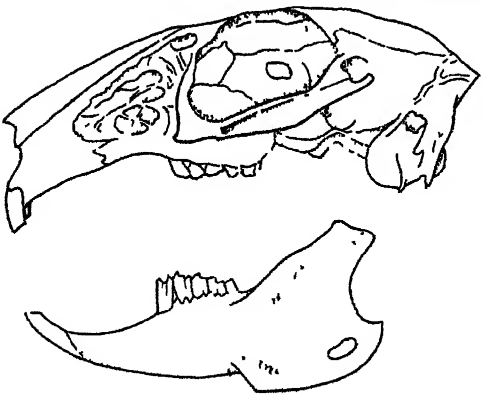


Fig. 13. A rodent, *Castor* (x 1/2)



The outstanding recognition character here is the small second incisor occurring on the upper jaw. Its presence is one of the major factors responsible for placing the rabbits and pikas in an order separate from the Rodentia. Note the "lacework" on the side of the ros-

Fig. 14. A lagomorph, *Sylvilagus* (x 3/4)

GLOSSARY

Abdominal pouch - Sac on external surface of abdomen of opossum, in which young are suckled.

Anal scent glands - Oil-secreting glands found on each side of anal opening in the Mustelidae.

Annulated - Ringed.

Anteriorly - Toward the front.

Arboreal - Tree-dwelling.

Carnassials - Scissor-like cutting teeth found in carnivores, comprising last premolar above and first molar below.

Carnivore - Member of the order Carnivora (meat-eaters).

Cheek pouches - Sacs on each side of face for carrying food.

Cheek teeth - Molars and premolars.

Cusp - Vertical projection on a tooth.

Dentition - An expression of the numbers and arrangement of teeth.

Diastema - Literally, a space; the space between the incisors and cheek teeth in rodents.

Distal - Away from the body (of limbs, tail, etc.).

Dorsal - Toward or of the upper surface.

Hispid - Of pelage, coarse or somewhat spiny.

Interfemoral membrane - In bats, skin connecting hind legs with tail.

Lateral - Away from the midline.

Length of ear - Distance from notch to tip.

Length of hind foot - From heel to tip of claw of longest toe.

Length of skull - Greatest antero-posterior length.

Length of tail - From posterior end of sacrum to end of last tail vertebra (see Fig. 1).

Loops - Enamel folds on grinding surface of cheek teeth in some rodents.

Mastoid breadth - Width of skull across mastoids.

Medial - Toward the midline.

Molariform - Molar-like.

Pelage - Hair or fur of a mammal.

Plantar tubercles - Projections on soles of feet.

Prismatic triangles - As loops, though with enamel sharply folded.

Proximal - Near the body (of limbs, tail, etc.).

Rami - Plural of ramus, the right or left half of the lower jaw.

Total length - Length from tip of nose to tip of last tail vertebra.

Unicuspid - Tooth having but one cusp or projection.

Ventral - Toward or of the lower surface.

Volant - Of gliding habit.

ANNOTATED LIST OF SPECIES AND SUBSPECIES

Under an accepted scientific name we have listed the original description of the species; a reference to a paper dealing with its natural history; locality records; and in some instances, notes of particular problems concerning the species in Illinois.

The list of localities includes specimens in collections designated as follows:

A	Chicago Academy of Sciences
B	U. S. Biological Surveys
D	Jane Claire Dirks, University of Illinois
F	Field Museum of Natural History
G	Tappan Gregory, Voltz Road, Winnetka, Illinois
I	Illinois State Natural History Survey, Urbana, Illinois
K	E. J. Koestner, University of Illinois
M	Museum of Zoology of the University of Michigan
MVZ	Museum of Vertebrate Zoology, University of California
N	United States National Museum
NU	Northwestern University
P	Academy of Natural Sciences of Philadelphia
R	R. Magoon Barnes, Lacon, Illinois
S	Southern Illinois Normal University, Carbondale
U	University of Illinois, Champaign

Added to this are additional definite records from the literature if there is an indication that the author actually had specimens. The author's name is added in parentheses and the complete title and reference will be found in the bibliography at the end of this paper. This list includes only species at present found in a wild state in Illinois.

In order to facilitate the locating of place names mentioned in the text, we have included a county map of Illinois (Fig. 15).

Fig. 15. County map of Illinois

ORDER **MARSUPIALIA**, MARSUPIALS

Family DIDELPHIIDAE, Opossums

Didelphis virginiana virginiana Kerr. Virginia Opossum.

Didelphis virginiana Kerr, 1792, Anim. Kingdom, p. 193.
Arthur, S. C., 1931, The fur animals of Louisiana, La. Dept. Cons., Bull., 18:77-85.

*Alexander**—Olive Branch, B, F. *Champaign*—Urbana, K, U. *Cook*—Chicago, NU; Hazel Crest, F; Northwood, G. *DuPage*—Glen Ellyn (Cory, Gregory); Naperville, F. *Ford*—Piper City, F, K. *Hancock*—Warsaw, N; West Frankfort, S. *Henry*—Kewanee, U. *Jasper*—Bogota, F. *Kane*—St. Charles, A. *Lake*—Deerfield, A; Highland Park, NU; Waukegan, A. *Marion*—Odin, F. *Mason*—Havana, K. *Ogle*—Oregon (Cory). *Union*—Wolf Lake, I. *Will*—Romeo, A. *Williamson*—Herrin, S.

ORDER **INSECTIVORA**, INSECTIVORES

Family TALPIDAE, Moles

Scalopus aquaticus machrinus Rafinesque. Prairie Mole.

Talpa machrina Rafinesque, 1832, Atlantic Journal, 1:61.
Arlton, A. V., 1936, An ecological study of the mole, Jour. Mamm., 17:349-371.

Adams—Quincy (West). *Alexander*—Olive Branch, F. *Calhoun*—Brussels (West). *Cass*—Virginia (West). *Champaign*—Urbana, K, U. *Clay*—Flora (West, Wood). *Cook*—Argyle Park, P; Brookdale, F; Chicago, F; Evanston, A, M; Harvey, F. *Cowles*—Charleston (Hankinson, West). *Ford*—Piper City, K. *Hancock*—Hamilton, N; Warsaw, F, N. *Hardin*—Rosiclare, F. *Jackson*—Carbondale, S; Murphysboro (West). *Jersey*—Riehl St., B. *Johnson*—Ozark, F. *Jo Daviess*—Hanover (West). *Kane*—Geneva, A. *Knox*—Galesburg (West). *Logan*—Atlanta (West); Lincoln (West); Mt. Pulaski (West). *McLean*—Bloomington (West); Normal (West). *Madison*—Alton, N. *Marion*—Odin (West). *Marshall*—Lacon, R. *Macon*—Decatur (West). *Mason*—Havana (West); Quiver Tp. (West, Wood). *Morgan*—Jacksonville (West). *Peoria*—Peoria (Brendel). *Piatt*—Monticello (West); White Heath (West, Wood). *Richland*—Calhoun, M; Olney, F, N; Parkersburg, N. *Rock Island*—Milan (West). *St. Clair*—Belleville, N; Mascoutah (West); St. Clair (West). *Shelby*—Windsor (West). *Union*—Alto Pass, U. *Vermilion*—Danville (West). *Will*—Joliet, F. *Williamson*—Marion (West).

*Names of counties are printed in italics.

Condylura cristata Linnaeus. Star-nosed Mole.

Sorex cristatus Linnaeus, 1758, Syst. Nat., ed. 10, p. 53.
Hamilton, W. J., Jr., 1931, Habits of the star-nosed mole, *Condylura cristata*, Jour. Mamm., 12:345-355.

Champaign—(Wood). *Hancock*—Warsaw (Cory).

This species, certainly easily recognizable, is found to all sides of Illinois; the sparsity of records within the state is inexplicable. Only Kennicott reports indirectly that it occurs in Edgar County.

Family SORICIDAE, Shrews

Sorex cinereus cinereus Kerr. Cinereous Shrew.

Sorex arcticus cinereus Kerr, 1792, Anim. Kingdom, p. 206.
Jackson, H. H. T., 1928, A taxonomic review of the American long-tailed shrews, N. Amer. Fauna, 51:40.

Cook—Calumet City, A; Calumet Lake, A; Chicago, NU; Glencoe, A; Niles Center, A; River Forest, A; West Northfield, N. *Kane*—Bowes, A. *Kankakee*—St. Anne, K. *Lake*—Beach, A; Camp Logan, F; Deerfield, A, NU; Fox Lake, F, NU; Grayslake, A; Highland Park, A, MVZ; Lake Forest, F; Pistakee Bay, F; Prairie View, A; Zion City, A.

Sorex longirostris longirostris Bachman. Bachman's Shrew.

Sorex longirostris Bachman, 1837, Acad. Nat. Sci. Phila., Jour., 7:370.
Jackson, H. H. T., 1928, A taxonomic review of the American long-tailed shrews, N. Amer. Fauna, 51:85.

Alexander—Olive Branch, F. *Johnson*—Reevesville, F.

The record of Wood for Pistakee Bay, McHenry County, may be a misidentification.

Blarina brevicauda carolinensis Bachman. Southern Short-tailed Shrew.

Sorex carolinensis Bachman, 1837, Acad. Nat. Sci. Phila., Jour., 7:366.
Hamilton, W. J., Jr., 1929, Breeding habits of the short-tailed shrew, *Blarina brevicauda*, Jour. Mamm., 10:125.

Alexander—Olive Branch, B, F. *Hardin*—Rosiclare, F. *Johnson*—Reevesville, F. *Massac*—Metropolis, F. *Piatt*—Monticello, A; White Heath, D. *Pope*—Golconda, B, F. *Pulaski*—Wetaug, F. *Union*—Alto Pass, U; Wolf Lake, A, B, F.

The specimens from Monticello, Piatt County, appear to be intergrades between this race and *talpoides*. In certain characters of pelage and external size they agree with *carolinensis*; in skull characters they approach *talpoides*.

Blarina brevicauda talpoides Gapper. Northern Short-tailed Shrew.

Sorex talpoides Gapper, 1830, Zool. Jour., 5:202.
Lyon, M. W., Jr., 1936, Mammals of Indiana, Amer. Midl. Nat., 17:47.

Champaign—Seymour, D; Urbana, U. *Cook*—Calumet City, A; Chicago, A, F; Des Plaines, N; Elk Grove, A; Elmwood Park, A; Forest View, A; Glencoe, A; Homewood, A, F; Indian Hill, G; Lemont, A; Mt. Clair, A; Northfield, N; New Lenox, A; Palos Park, A; Ravinia, MVZ; River Forest, A; Thatcher's Woods, A; West Northfield, N; Worth, F. *Coles*—Charleston (Hankinson). *De Kalb*—De Kalb, B; Somonauk, A. *DuPage*—Glen Ellyn (Gregory). *Ford*—Piper City, K. *Iroquois*—(Wood). *Jo Daviess*—Galena, F. *Kane*—Bowes, A; Sugar Grove, A. *Lake*—Camp Logan, F; Deerfield, A; Fox Lake, F; Grayslake, A; Highland Park, A, MVZ; Pistakee Lake, NU; Prairie View, A; Waukegan, A, N. *McHenry*—(Wood). *Marshall*—Lawn Ridge, M. *Ogle*—White Pines St. Park, U. *Warren*—(Wood).

Microsorex hoyi hoyi Baird. American Pigmy Shrew.

Sorex hoyi Baird, 1857, Rep. Pacific R. R. Survey, 8: pt. 1, Mammals, p. 22.
Jackson, H. H. T., 1928, A taxonomic review of the American long-tailed shrews, N. Amer. Fauna, 51:202.

This species has not been definitely recorded from Illinois, but since its type locality is just a few miles north of our boundaries we include it because it is very apt to be found.

Cryptotis parva Say. Least Shrew.

Sorex parvus Say, 1923, Long's Expedition Rocky Mts., 1:163.
Merriam, C. H., 1895, Revision of the shrews of the American genera *Blarina* and *Notiosorex*, N. Amer. Fauna, 10:17.

Alexander—Olive Branch, F. *Champaign*—Champaign (Mohr, 1935); Seymour, K; Urbana, K. *Coles*—Charleston (Cory, Hankinson). *Cook*—Homewood, F. *Crawford*—Flat Rock, A. *Hancock*—Warsaw, F. *Johnson*—Reevesville, F. *Mason*—(Wood). *McLean*—Bloomington, B. *Piatt*—White Heath, D, K. *Union*—Wolf Lake, A.

ORDER CHIROPTERA, BATS

Allen, Glover M., Bats. Harvard University Press. 1939.

Myotis lucifugus lucifugus Le Conte. Little Brown Bat.

Vespertilio lucifugus Le Conte, 1831, McMurtrie's Cuvier, Anim. Kingdom, 1:431.
Miller, G. S., Jr., and G. M. Allen, 1928, The American bats of the genera *Myotis* and *Pizonyx*, U. S. Nat. Mus. Bull., 144:43.

Carroll—Savanna, I. *Champaign*—Urbana, K, U. *Cook*—Chicago, A, F; Evanston (Gregory); West Northfield, N. *DuPage*—Naperville, A. *Hancock*—Warsaw, N. *Hardin*—Rosiclare (Cory). *Jackson*—Carbondale, I, S. *Jo Daviess*—Apple River Canyon St. Park, I. *Kane*—Sugar Grove, A. *Lake*—Waukegan, F. *Macon*—Harristown, N. *Mason*—Havana, I, U. *Ogle*—(Miller and Allen). *Pope*—Golconda, F.

Myotis grisescens Howell. Gray Bat.

Myotis grisescens Howell, 1909, Biol. Soc. Wash., Proc., 22:46.
Miller and Allen, U. S. Nat. Mus. Bull., 144:105.

Hardin—Rosiclare, F.

Myotis keenii septentrionalis Trouessart. Big-eared Little Brown Bat.

Vespertilio gryphus var. *septentrionalis* Trouessart, 1897, Cat. Mamm. Viv. Foss., p. 131.
Miller and Allen, U. S. Nat. Mus. Bull., 144:105.

Cook—Chicago, F, N. *Gallatin*—Equality, S. *Rock Island*—Rock Island, U. *Wabash*—N.

Myotis sodalis Miller and Allen. Indiana Bat.

Myotis sodalis Miller and Allen, 1928, U. S. Nat. Mus. Bull., 144:130.
Miller and Allen, U. S. Nat. Mus. Bull., 144:130.

Hardin—Rosiclare, F.

Lasionycteris noctivagans Le Conte. Silver-haired Bat.

Vespertilio noctivagans Le Conte, McMurtrie's Cuvier, Anim. Kingdom, 1:431.
Seton, E. T., 1909, Life histories of northern animals, Scribner's, 2:1166.

Champaign—Urbana, D, K. *Cook*—Chicago, A; Evanston, A, NU; Jackson Park, F; Lincoln Park, A; Palos Park (Cory). *DuPage*—Glen Ellyn, F; Milton Tp. (Gregory). *Ford*—Piper City, K. *Grundy*—Morris, U. *Hancock*—Warsaw, N. *Lake*—A, Beach, F; Highland Park, F. *Richland*—Olney, N. *Whiteside*—Sterling, I.

Pipistrellus subflavus subflavus Cuvier. Georgian Bat.

Vespertilio subflavus Cuvier, Mus. Hist. Nat. Paris, Nouv. Ann., 1:17.
Miller, G. S., Jr., 1897, Revision of the North American bats of the family Vespertilionidae, N. Amer. Fauna, 13:90.

Adams—Quincy, I. *Alexander*—Olive Branch, B, F, N. *Champaign*—Urbana, K. *Coles*—Charleston (Cory). *Gallatin*—Equality, S. *Hardin*—Rosiclare, F. *Jackson*—Kincaid Cave, S. *Jersey*—Grafton, I, K. *Johnson*—Ozark, F. *Pope*—Golconda, F. *Richland*—Olney, B. *Union*—Alto Pass, U; Anna, F; Lick Creek, B, N.

Eptesicus fuscus fuscus Palisot de Beauvois. Big Brown Bat.

Vespertilio fuscus Palisot de Beauvois, 1796, Catal. Raisonné Mus. Peale, Phila., p. 18.
Seton, E. T., 1909, Life histories of northern animals, Scribners, 2:1177.

Adams—Quincy, I. *Champaign*—Champaign, K, U. *Cook*—Chicago, F. *DuPage*—Sugar Mound, A. *Hancock*—Warsaw, B. *Jackson*—B. *Jo Daviess*—Galena, I. *Kane*—Sugar Grove, A, NU. *Lake*—Lake Bluff, A. *Peoria*—Peoria, B. *Richland*—N.

Lasiurus borealis borealis Müller. Northern Red Bat.

Vespertilio borealis Muller, Natursyst. Suppl., p. 20.
Seton, E. T., 1909, Life histories of northern animals, Scribners, 2:1183.

Alexander—Olive Branch, F. *Champaign*—Urbana, D, K, U. *Cook*—Chicago, A, F, N, NU; Evanston, A; La Grange, A; Lincoln Park, A; Maywood, F; Niles Center, F; Willow Springs, F; West Northfield (Miller, 1897). *DuPage*—Naperville, A; Glen Ellyn (Gregory). *Ford*—Piper City, K. *Hancock*—Warsaw, N. *Hardin*—Rosiclare, F. *Jackson*—Carbondale, S. *Lake*—Highland Park, F; Lake Forest, F; Waukegan, N. *Marshall*—Lacon, R. *Richland*—Olney, N. *Union*—Pomona, S. *Wabash*—Mt. Carmel, N.

Lasiurus cinereus Palisot de Beauvois. Hoary Bat.

Vespertilio cinereus Palisot de Beauvois, 1796, Catal. Raisonné Mus. Peale, Phila., p. 18.
Seton, E. T., 1909, Life histories of northern animals, Scribners, 2:1191.

Champaign—Urbana, K. *Coles*—Charleston (Cory). *Cook*—Chicago, F, M; Flossmoor, F; Maywood, F. *DuPage*—Wheaton, A. *Ford*—Piper City, K. *Grundy*—Morris, U. *Hancock*—Warsaw, N. *Richland*—Olney, N. *Wabash*—N.

Nycticeius humeralis Rafinesque. Rafinesque's Bat.

Vespertilio humeralis Rafinesque, 1818, Amer. Monthly Mag., 3:445.
Miller, G. S., Jr., Revision of the North American bats of the family Vespertilionidae, N. Amer. Fauna, 13:118.

Alexander—Olive Branch, F, N. *Champaign*—Urbana, K, U. *Cook*—Chicago, F. *DuPage*—Sugar Mound, A. *Ford*—Piper City, K. *Hancock*—Warsaw, N. *Wabash*—N.

Corynorhinus rafinesquii rafinesquii Lesson. Big-eared Bat.

Plecotus rafinesquii Lesson, 1827, Man. de Mamm., p. 96.
Lyon, M. W., Jr., 1936, Mammals of Indiana, Amer. Midl. Nat., 17:85.

Wabash—Mt. Carmel, N.

ORDER CARNIVORA, CARNIVORES

Family PROCYONIDAE, Raccoons

Procyon lotor hirtus Nelson and Goldman. Raccoon.

Procyon lotor hirtus Nelson and Goldman, Jour. Mamm., 11:455.
Whitney, L. F., 1931, The raccoon and its hunting, Jour. Mamm., 12:29.

Alexander—Olive Branch, F. *Champaign*—(Wood). *Cook*—Evanston, A; Jackson Park, F. *Ford*—Piper City, K. *Hardin*—Rosiclare, F. *Henderson*—N. *Macon*—Decatur, U. *Marshall*—Lacon, R. *St. Clair*—Belleville, N. *Will*—Joliet, F; Lockport, A.

Family MUSTELIDAE, Weasels

Mustela rixosa allegheniensis Rhoads. Least Weasel.

Putorius allegheniensis Rhoads, 1901, Acad. Nat. Sci. Phila., Proc., 1900:751.
Seton, E. T., 1929, Lives of game animals, Doubleday Doran, 2:634.

Cook—La Grange, A; Niles Center, A; Northfield Tp., F; Wheeling, A. *Lake*—Beach, F; Deerfield, A, F; Grayslake, A; Highland Park, A, G; Waukegan, A; Zion, A. *Lee*—Henkle, I. *McHenry*—Woodstock, G.

Mustela frenata noveboracensis Emmons. Long-tailed Weasel.

Putorius noveboracensis Emmons, 1840, Rep. Quadrupeds Mass., p. 45.
Hamilton, W. J., Jr., 1933, The weasels of New York, Amer. Midl. Nat., 14:289.

Champaign—Seymour, K. *Cook*—Evanston, A; Flossmoor, F; Glencoe, F; Lemont, A; La Grange, G; Niles Center, A; Wheeling, A. *Ford*—Piper City, K. *Lake*—Camp Logan, F; Deerfield, A; Fort Sheridan, F; Highland Park, A; Pistakee Lake, A. *Livingston*—Chatsworth, K. *Marshall*—Lacon, R. *Peoria*—Peoria, M. *Piatt*—White Heath, D. *Pike*—Bloomingdale Spring, F; Milton Spring, F. *Pope*—Golconda, B. *Vermilion*—Catlin, K. *Will*—Joliet, A.

Mustela vison mink Peale and Palisot de Beauvois. Eastern Mink.

Mustela mink Peale and Palisot de Beauvois, 1796, Cat. Peale Mus., p. 39.
Seton, E. T., 1929, Lives of game animals, 2:518.

Hancock—Warsaw, F. *St. Clair*—Belleville, N.

Mustela vison letifera Hollister. Mississippi Valley Mink.

Mustela vison letifera Hollister, 1913, U. S. Nat. Mus., Proc., 44:475.
Seton, E. T., 1929, Lives of game animals, 2:518.

Champaign—Urbana, U. *Cook*—Evanston, A; Oak Park, N; Orland, F. *DuPage*—Addison, Bloomington, and Milton Tps. (Gregory). *Ford*—Piper City, K. *Kane*—Geneva, A. *Lake*—Deerfield, A, F; Grayslake, A. *Marshall*—Lacon, R.

The subspecific status of minks in Illinois needs further clarification.

Mephitis mephitis minnesotae Brass. Minnesota Skunk.

Mephitis minnesotae Brass, 1911, Aus dem Reiche der Pelze, p. 532.

Mephitis mephitis avia Bangs. Illinois Skunk.

Mephitis avia Bangs, 1898, Biol. Soc. Wash., Proc., 12:32.
Seton, E. T., 1929, Lives of game animals, 2:309.

Champaign—Homer, I; Urbana, U. *Coles*—Charleston (Hankinson). *Cook*—Chicago, B, F; Evanston, B; Oak Park, B. *DuPage*—York Tp. (Gregory). *Ford*—Piper City, K. *Jo Daviess*—Galena, F. *Lake*—Camp Logan, F; Deerfield, A; Highland Park, F; Waukegan, A; Waukegan Flats, A. *McHenry*—Alden, B; Huntley, A. *Piatt*—De Land, K. *Stephenson*—Freeport, N. *Vermilion*—Catlin, U.

The status of the species making up the genus *Mephitis* being somewhat in doubt, so far as Illinois is concerned, we have deemed it best to lump the available records, pending further study.

Taxidea taxus taxus Schreber. Badger.

Ursus taxus Schreber, 1778, Saugthiere, 3:520.
Seton, E. T., 1929, Lives of game animals, 2:286.

Cook—Chicago, F. *DuPage*—Milton (Gregory). *Kankakee*—K. *Lake*—4 mi. NW Barrington, F; Halfday (Gregory). *Lee*—Dixon, I.

Family CANIDAE, Dogs

Vulpes fulva Desmarest. Red Fox.

Canis fulvus Desmarest, 1820, Mammalogie, 1:203.
Seton, E. T., 1929, Lives of game animals, 1:469.

Champaign—(Wood). *Ford*—Piper City, K. *Will*—Joliet, F; Wilmington, F. "Southern Illinois," A.

Urocyon cinereoargenteus cinereoargenteus Schreber.
Gray Fox.

Canis cinereo argenteus Schreber, 1775, Saugthiere, pl. 92.
Seton, E. T., 1929, Lives of game animals, 1:568.

Alexander—(Cory). *Champaign*—(Wood). *Christian*—(Cory). *Hardin*—(Cory). *Lake*—Deerfield (Gregory). *Menard*—Near Petersburg, F. *Richland*—Parkersburg, N. *Union*—(Cory). *Wabash*—Mt. Carmel, N.

Canis latrans latrans Say. Coyote.

Canis latrans Say, 1823, Long's Exped. Rocky Mts., 1:168.
Seton, E. T., 1929, Lives of game animals, 1:355.

Champaign—(Wood). *Kane*—Geneva (Cory). *Lake*—Halfday (Gregory); Lake Forest, A. *Marshall*—9 mi. W. Henry, B; Lacon, R.

Family FELIDAE, Cats

Lynx rufus rufus Schreber. Bobcat.

Felis rufa Schreber, 1777, Saugthiere, pl. 109b.
Seton, E. T., 1929, Lives of game animals, 1:212.

The inclusion of the bobcat in the fauna of Illinois is based on a supposed recent record from Prairie du Rocher, Randolph County, verification of which we have been unable to obtain. Inasmuch as *Lynx rufus* occurs in Missouri directly across the Mississippi River it seems reasonable to assume that it also occurs in this state.

ORDER RODENTIA, RODENTS

Family SCIURIDAE, Squirrels

Marmota monax monax Linnaeus. Woodchuck.

Mus monax Linnaeus, 1758, Syst. Nat., ed. 10, 1:60.
Hamilton, W. J., Jr., 1934, The life history of the rufescent woodchuck, *Marmota monax rufescens*, Carnegie Mus., Ann., 23:85-178.

Champaign—Urbana, U. *Cook*—Chicago, A; Lemont, A; Willow Springs, F. *DeKalb*—Somonauk, A. *DuPage*—Bloomingdale and Milton Tps., (Gregory). *Effingham*—Watson, I. *Henry*—Kewanee, U. *Johnson*—Ozark, F. *Kane*—St. Charles, A. *Lake*—Fremont Tp., A; Fox Lake, F; Lake Forest, F. *Ogle*—Grand Detour, F. *Peoria*—Peoria (Brendel). *Stark*—Toulon, B, I. *Vermilion*—Georgetown, U. *Warren*—Gladstone, F.

Citellus tridecemlineatus triedecemlineatus Mitchill.
Thirteen-lined Ground Squirrel.

Sciurus tridecem lineatus Mitchill, 1821, Med. Repos., (N. S.), 6:248.
Howell, A. H., 1938, Revision of the North American ground squirrels, N. Amer. Fauna, 56:107.

Carroll—Mt. Carroll (Allen). *Champaign*—Champaign, K, U. *Cook*—4 mi. N. Bartlett, A; Chicago, A, F, N; Evanston (Allen); Forest Park, A; Forest View, A; Lemont, A; River Forest, A; Worth, F. *Coles*—Charleston (Hankinson). *DuPage*—Bloomingdale Tp. (Gregory); Glen Ellyn (Gregory). *Ford*—Piper City, K; Roberts, K. *Hancock*—Warsaw, N. *Kane*—Bowes, A. *Lake*—Beach, A, F; Fox Lake, F; Grayslake, A, F. *Marshall*—Lacon, R; Lawn Ridge, M. *Ogle*—(Allen). *Peoria*—Peoria (Allen, Brendel). *Will*—Near Lemont, A; Wheatland Tp., M. *Winnebago*—Fauntaindale (Kennicott); Pecantonica, A. *Woodford*—Washburn, I.

Citellus franklinii Sabine. Franklin Ground Squirrel.

Arctomys franklinii Sabine, 1822, Linn. Soc., London, Trans., 13:587.
Howell, A. H., 1938, Revision of the North American ground squirrels, N. Amer. Fauna, 56:133.

Adams—Payson (Kennicott). *Carroll*—Mt. Carroll (Allen, Cory). *Champaign*—Champaign, U; Urbana, U. *Coles*—Charleston (Hankinson). *Cook*—Barrington, A; Chicago, NU; Evanston, NU; La Grange, NU; Lemont, A; Orland Park, NU; Palos Park, NU; West Northfield, N; Worth, F. *DuPage*—Bloomingdale and Milton Tps. (Gregory); Hinsdale, NU. *Ford*—Piper City, K. *Henry*—Kewanee, NU. *Kane*—(Cory). *Lake*—Grayslake, A. *LaSalle*—Vermilion River, N. *Marshall*—Lacon, R; Lawn Ridge (Allen). *Peoria*—Peoria, NU. *St. Clair*—(Cory). *Will*—Joliet, NU; Near Lemont, A; 6 mi. S. Naperville, F; Romeo, A. *Tazewell*—Tremont, NU. *Winnebago*—Pecatonica (Cory, Kennicott).

Tamias striatus griseus Mearns. Chipmunk.

Tamias striatus griseus Mearns, 1891, Amer. Mus. Nat. Hist., Bull., 3:231.
Howell, A. H., 1929, Revision of the American chipmunks, N. Amer. Fauna, 52:20.

Carroll—Mt. Carroll (Allen). *Champaign*—Urbana, K. *Cook*—Evanston, A; Northfield Tp. (Gregory, 1930); River Forest, A. *DuPage*—Hinsdale, NU; Milton Tp. (Gregory). *Hancock*—Warsaw, N. *Lake*—Fox Lake, A, F; Highland Park, A; Pistakee Bay, F. *Marshall*—Lacon, R. *Peoria*—Peoria (Brendel). *Piatt*—White Heath (Koestner). *Sangamon*—Sherman, I. *Vermilion*—Oakwood, I. *Wabash*—Mt. Carmel, N. *Will*—Romeo, A.

Tamiasciurus hudsonicus loquax Bangs. Red Squirrel.

Sciurus hudsonicus loquax Bangs, 1896, Biol. Soc. Wash., Proc., 10:161.
Hatt, R. T., 1929, The red squirrel, Roosevelt Wildlife Ann., 2:1-146.

Iroquois—Onarga (Wood). *Lake*—Lake Forest, F; Fox Lake (Cory). *Marshall*—Lawn Ridge (Allen). *Putnam*—Hennepin (Kennicott).

Sciurus carolinensis carolinensis Gmelin. Southern Gray Squirrel.

Sciurus carolinensis Gmelin, 1788, Syst. Nat., 1:148.
Seton, E. T., 1929, Lives of game animals, 4:9.

Alexander—Olive Branch, B, F. *Johnson*—Belknap, S. *Pulaski*—Ullin, G. *Richland*—Parkersburg, N. *Union*—(Allen, as *leucotis*).

Sciurus carolinensis leucotis Gapper. Northern Gray Squirrel.

Sciurus leucotis Gapper, 1830, Zool. Jour., 5:206.
Seton, E. T., 1929, Lives of game animals, 4:9.

Carroll—Mt. Carroll (Allen). *Champaign*—(Wood). *Cook*—Chicago, A; Glencoe, A; Lincoln Park, A; Palos Park, A; West Northfield, N. *DuPage*—Glen Ellyn, A. *Jasper*—Newton, U. *Lake*—Deerfield, A; Highland Park, A, F; Lake Forest, A, F. *Marshall*—Lacon, R. *Peoria*—Peoria (Brendel). *Rock Island*—Milan, I.

Sciurus niger rufiventer Geoffroy. Fox Squirrel.

Sciurus rufiventer Geoffroy, 1803, Cat. Mamm. Mus. Hist. Nat., Paris, p. 176.
Seton, E. T., 1929, Lives of game animals, 4:82.

Boone—Belvedere, A. *Carroll*—Mt. Carroll (Allen). *Champaign*—Champaign, K; Urbana, D, U. *Cook*—Bartlett, A; Berwyn, A; Chicago, F; Chicago Heights, F; Deer Grove, NU; Palos Park, A; West Northfield (Allen). *Cumberland*—Neoga, U. *DuPage*—Milton Tp. (Gregory). *Ford*—Piper City, K. *Hancock*—Warsaw, F, N. *Henry*—Geneseo, F. *Lake*—Antioch, A; Deerfield, A; Fox Lake, F; Fremont (Allen); Grayslake, A; Highland Park, A; Lake Forest, F. *Lawrence*—Jackson (Allen). *McHenry*—Greenwood, A; Woodstock, F. *Marshall*—Lacon, R. *Ogle*—Marion (Allen); Mt. Morris, F. *Peoria*—Peoria, N. *Piatt*—Monticello, A; White Heath, K. *Richland*—Parkersburg, N. *Wabash*—Mt. Carmel, N. *Williamson*—Near Hurst, S.

Glaucomys volans volans Linnaeus. Flying Squirrel.

Mus volans Linnaeus, 1758, Syst. Nat., ed. 10, 1:63.

Sollberger, D. E., 1940, Notes on the life history of the small eastern flying squirrel, Jour. Mamm., 21:282.

Alexander—Olive Branch, F. *Carroll*—Thomson, K. *Champaign*—(Wood). *Cook*—Chicago, N; Evanston, A; West Northfield, M; Willow Springs, F. *DuPage*—Bloomingdale (Gregory). *Hancock*—Warsaw, F, N. *Jackson*—Carbondale, S. *Kane*—Geneva, NU; St. Charles, A. *Kankakee*—Pembroke Tp., A. *Lake*—Deerfield, A, F; Halfday, A; Highland Park, F; Lake Forest, A; Waukegan, A. *LaSalle*—Starved Rock, I. *Marshall*—Lacon, R; Lawn Ridge (Allen). *Mason*—Havana, A. *Peoria*—Peoria (Allen, Brendel). *Piatt*—White Heath, D, K, U. *Pope*—Golconda, F. *Pulaski*—Wetaug, A. *Richland*—Olney, B, N; Parkersburg, N. *Rock Island*—Moline (Fryxell, 1936). *St. Clair*—Belleville, N.

Family GEOMYIDAE, Pocket Gophers

Geomys bursarius illinoensis Komarek and Spencer. Illinois Pocket Gopher.

Geomys bursarius illinoensis Komarek and Spencer, 1931, Jour. Mamm., 12:405.

Wight, H. M., 1918, The life history and control of the pocket gopher in the Willamette Valley, Oregon Agri. Coll. Exp. Sta. Bull. 153.

DeWitt—Clinton, N. *Kankakee*—Aroma Park, F; Bonfield, F; Hopkins Park, A, G; Momence, A; Pembroke Tp., F; St. Anne, A. *LaSalle*—Oglesby, A; Ottawa, A; Utica, A. *Marshall*—Lacon, A, F, R. *Mason*—Havana, B; San Jose, F. *Tazewell*—Tremont, N. *Will*—Custer Park, A. *Woodford*—Kappa, I.

Family CASTORIDAE, Beavers

Castor canadensis Kuhl. Beaver.

Castor canadensis Kuhl, 1820, Beitr. Zool., p. 64.

Bradt, G. W., 1938, A study of beaver colonies in Michigan, Jour. Mamm., 19:139.

The beaver was exterminated in the state and has recently been reintroduced.

Family CRICETIDAE, New World Rats and Mice

Peromyscus maniculatus bairdii Hoy and Kennicott. Prairie White-footed Mouse.

Mus bairdii Hoy and Kennicott, 1857, U. S. Patent Off. Rep., (agri.) 1856:92.
Osgood, W. H., 1909, Revision of the mice of the American genus *Peromyscus*, N. Amer. Fauna, 28:79.

Alexander—McClure, B; Olive Branch, B, F. *Champaign*—Seymour, K; Urbana, M. *Coles*—Charleston (Hankinson). *Cook*—Calumet City, A; Chicago, F; Forest View, A; Lemont, A; River Forest, A; West Northfield, M, N. *DuPage*—Bloomingdale Tp. (Gregory). *Edgar*—Kansas, B. *Ford*—Piper City, K. *Jersey*—Riehl Sta., B. *Johnson*—Reevesville, F. *Lake*—Beach, A, F; Fox Lake, F; Fremont (Coues); Highland Park, MVZ; Ravinia, MVZ; Waukegan, A. *McLean*—Bloomington (Kennicott). *Marion*—Salem, I. *Piatt*—K. *Richland*—Parkersburg, B, N. *Rock Island*—6 mi. E. Cordova, G. *Vermilion*—Hoopeston, A.

Peromyscus leucopus leucopus Rafinesque. Southern Woodland White-footed Mouse.

Musculus leucopus Rafinesque, 1818, Amer. Monthly Mag., 3:446.
Osgood, W. H., 1909, Revision of the mice of the American genus *Peromyscus*, N. Amer. Fauna, 28:113.

Alexander—Cypress Jct., McClure, B; Horseshoe Lake, U; Olive Branch, F, U; Wolf Lake, A. *Crawford*—Flat Rock, A. *Gallatin*—Shawneetown, B. *Johnson*—Reevesville, B, F; Ozark, F. *Massac*—Metropolis, A. *Pope*—Golconda, B, F. *Pulaski*—Wetaug, A. *Union*—Alto Pass, U.

Peromyscus leucopus noveboracensis Fischer. Northern Woodland White-footed Mouse.

Mus sylvaticus noveboracensis Fischer, 1829, Syn. Mamm., p. 318.
Nicholson, A. J., 1941, The homes and social habits of the wood mouse *(Peromyscus leucopus noveboracensis)* in Southern Michigan, Amer. Midl. Nat., 25:196.

Adams—Quincy, I. *Calhoun*—Brussels, I. *Champaign*—Urbana, K, U. *Coles*—Charleston (Hankinson). *Cook*—Bartlett, A; Calumet City, A; Elk Grove, A; Glencoe, A; Lemont, A; Maywood, A; Northfield Tp. (Gregory, 1928); Palos Park, A; Prairie View, A; River Forest, A; West Northfield (Coues, Osgood). *De Kalb*—Somonauk, A. *DuPage*—Glen Ellyn (Gregory); Naperville, A. *Fayette*—Hagarstown, I. *Ford*

—Piper City, K. *Hancock*—Warsaw, N. *Henderson*—N. *Henry*—Geneseo, U. *Jersey*—Riehl Sta., B. *Jo Daviess*—Galena, F. *Kane*—Bowes, A. *Kankakee*—Aroma Park, K; Hopkins Park, A; Near St. Anne, A, K. *Lake*—Beach, A; Camp Logan, F; Deerfield, A, F; Pistakee Bay, F. *Marshall*—Lacon, R. *Ogle*—Polo, A. *Piatt*—Monticello, A; White Heath, D, K, U. *Richland*—Olney, B; Parkersburg, B. *Vermilion*—Catlin, U. *Will*—New Lenox, A, F.

Studies of the intergradation of the two subspecies of *Peromyscus leucopus* are needed.

Peromyscus gossypinus megacephalus Rhoads. Cotton Mouse.

Sitomys megacephalus Rhoads, 1894, Acad. Nat. Sci. Phila., Proc., 1894:254.
Osgood, W. H., 1909, Revision of the mice of the American genus *Peromyscus*, N. Amer. Fauna, 28:135.

Alexander—Olive Branch, F. *Johnson*—Ozark, F. *Pope*—Golconda, F. *Pulaski*—Wetaug, A.

Peromyscus nuttalli aureolus Audubon and Bachman. Southern Golden Mouse.

Mus (Calomys) aureolus Audubon and Bachman, 1841, Acad. Nat. Sci. Phila., Proc., 1:98.
Osgood, W. H., 1909, Revision of the mice of the American genus *Peromyscus*, N. Amer. Fauna, 28:224.

Alexander—Cairo (Coues); Olive Branch, B, F. *Jackson*—(Wood). *Marion*—(Wood).

Oryzomys palustris palustris Harlan. Swamp Rice Rat.

Mus palustris Harlan, 1837, Amer. Jour. Sci., 31:385.
Goldman, E. A., 1918, The rice rats of North America, N. Amer. Fauna, 42:22.

Alexander—Cache, I; Olive Branch, N, F.

Neotoma floridana illinoensis Howell. Illinois Wood Rat.

Neotoma floridana illinoensis Howell, 1910, Biol. Soc. Wash., Proc., 23:28.
Poole, E. L., 1940, A life history sketch of the Allegheny woodrat, Jour. Mamm., 21:249.

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A. *Richland*—Olney, B. *Union*—Wolf Lake, A, B. *Vermilion*—Rankin, I; Danville, U. *Will*—New Lenox, A.

Pitymys pinetorum scalopsoides Audubon and Bachman. Northern Pine Mouse.

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Pitymys pinetorum auricularis Bailey. Southern Pine Mouse.

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Ondatra zibethicus zibethicus Linnaeus. Muskrat.

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Alexander—Olive Branch, B. *Carroll*—Savanna, B. *Champaign*—Champaign, K, U; Seymour, U; Urbana, U. *Christian*—Mt. Auburn, U. *Cook*—Chicago, F; Jackson Park, F; Lemont, A; Orland Park, A; Skokie Marsh, A. *DuPage*—Milton Tp. (Gregory). *Ford*—Piper City, K. *Hancock*—Warsaw, F. *Lake*—Deerfield, A; Fox Lake, F; Highland Park (Gregory); Libertyville, F; Waukegan, F. *McHenry*—Near Cary, NU. *Marshall*—Lacon, R. *Piatt*—K. *Vermilion*—Fairmount, U.

Family MURIDAE, Old World Rats and Mice

Rattus rattus rattus Linnaeus. Black Rat.

Rattus norvegicus Erxleben. Norway Rat.

Mus musculus musculus Linnaeus. House Mouse.

The above three species are all imported and apt to be found wherever man is. The black rat occurs to the south and the Norway rat to the north.

Family ZAPODIDAE, Jumping Mice

Zapus hudsonius hudsonius Zimmermann. Jumping Mouse.

Dipus hudsonius Zimmermann, 1780, Geog. Gesch., 2:358.
Hamilton, W. J., Jr., 1935, Habits of jumping mice, Amer. Midl. Nat., 16:187.

Cook—West Northfield (Coues, 1877). *Jackson*—Carbondale, S. *Jo Daviess*—Near Galena, F. *Kane*—Sugar Grove, A. *Lake*—Deerfield (Gregory); Fox Lake, F. *Marshall*—Lacon, R.

Family ERETHIZONTIDAE, Porcupines

Erethizon dorsatum dorsatum Linnaeus. Canada Porcupine.

Hystrix dorsata Linnaeus, 1758, Syst. Nat., ed. 10, 1:57.

We agree with Mr. Davis that the specimen recorded by him from Illinois (1933) is most likely an escape. We do not consider the species to be a member of the Illinois fauna at the present time.

ORDER LAGOMORPHA, RABBITS

Family LEPORIDAE, Rabbits

Sylvilagus floridanus mearnsii Allen. Mearns Cottontail Rabbit.

Lepus sylvaticus mearnsii Allen, 1894, Amer. Mus. Nat. Hist., Bull., 6:171.
Allen, D. L., 1939, Michigan cottontails in winter, Jour. Wildlife Management, 3:307. Hendrickson, G. O., 1936, Summer studies of the cottontail rabbit, Iowa State College Jour. Sci., 10:367.

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Sylvilagus floridanus alacer Bangs. Southern Cottontail Rabbit.

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AN ECOLOGICAL STUDY OF THE FLOOR FAUNA OF THE PANAMA RAIN FOREST

BY

ELIOT C. WILLIAMS, JR.

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AN ECOLOGICAL STUDY OF THE FLOOR FAUNA OF THE PANAMA RAIN FOREST*

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INTRODUCTION

The several parts of a biotic community must be studied intensively before the ecology of the entire community can be understood. Inasmuch as the floor stratum is an important component of a forest community, it was felt that a quantitative faunal study of this stratum coupled with an analysis of the environmental factors would yield results which would be a definite addition to our knowledge of the tropical rain forest.

The only comprehensive study of the surface fauna in the tropics known to the author is that of Dammerman (1925, 1937). The main object of this work was the determination of the number of species present on a given area. This research was carried out in various islands of the East Indies. Dammerman's method of collection was mainly a careful sorting out of the animals from the debris on one square meter. He treated a few samples in a Berlese Funnel. The samples sorted by hand ran about 120 individuals per square meter, but these figures are low because exact counts were not made of species which were represented by many specimens. The samples which were treated by the Berlese method yielded about 700 individuals per square meter. There was an average of 25 species for each square meter with a maximum of 88 species and a minimum of 4. A peak in number, both of species and individuals, was reached at the height of the rainy season. Beebe (1916) collected the material from four square feet in the Brazilian rain forest and examined it while en route to New York. Ants comprised 30 per cent of the total collections. The results for Acarina and Collembola were low,

*Contribution from the Zoological Laboratories of Northwestern University.

mainly because his technique would not yield good results for such minute forms. In all, he found 500 specimens and estimated that there were at least twice as many which had not been collected. On this basis there were about 4,000 animals per square meter.

A fairly substantial body of literature has been built up concerning the fauna of the soil and its surface. These various investigations fall into two main categories, qualitative and quantitative. Although much of the earlier work dealt with the obvious question of what kinds of animals inhabit the soil and surface debris, in more recent years methods were gradually perfected for determining the number of animals in this stratum. It is not possible here to give a complete review of the literature but a bibliography is included in which a large portion of the pertinent material is cited.

The collections upon which this study is based were made on Barro Colorado Island, Gatun Lake, Panama Canal Zone, during July and August of 1938. This island was formed in 1914 when the Gatun Dam backed up the waters of the Chagres River to make Gatun Lake, the central portion of the Panama Canal. The higher regions of the former valley were left as islands in the lake, Barro Colorado being the largest one. The greatest length and width of the island are approximately 3 miles, and the area is 6.64 square miles. Due to irregularities, the shore line is over 40 miles long. The highest point on the island is 537 feet above sea level, 452 feet above Gatun Lake.

The annual rainfall (1926-1930) was 100.10 inches, 7.06 inches of which fell in the first four months of the year. With rare exceptions the temperature ranges from 70 degrees to 90 degrees Fahrenheit. The mean daily temperature remains practically the same from month to month, while the daily range varies from 5 to 15 degrees Fahrenheit. Relative humidity fluctuates between 77 per cent in the dry season and 88 per cent in June, July, and August. The above description is based, in part, on that given by Enders (1935).

In regard to the forest itself, Enders quotes Kenoyer (1929, p. 201) as follows: "About half of it (the forest covering the island), that farthest from the Canal, is apparently primeval forest, although Standley (1927) points out that in a region which has been for over 400 years an important trade route it is difficult to prove that a given tract of land has not at some time been cleared and put under cultivation. The other half is occupied mainly by secondary forest, the largest trees of which scarcely exceed a foot in diameter at the base. Apparently it has become forested from a cleared condition of about fifty years ago." Enders prepared a map, showing the areas considered to be primeval and those which are

second growth. Most of the samples taken in the course of this study were from areas represented by Enders as primeval forest.

The specific portion of the habitat with which we are here concerned is the forest floor. The lack of undergrowth in the rain forest is especially noticeable to one familiar with the northern deciduous forest. There are very few herbs and for the most part the ground is devoid of low-growing plants. The stratification typical of all forests is present in the tropical rain forest (Allee, 1926), but the first living plant stratum of any importance, passing from the ground upward, is that of the higher shrubs (to ten feet). The litter on the floor of the forest is made up of dead leaves, twigs and other plant products, and the feces and remains of animals.

MATERIALS AND METHODS

Eleven large quadrats, one meter square, were examined in the field. A frame which enclosed an area of exactly one square meter was placed on the ground and all of the living vegetation was removed and weighed. The forest floor litter was next carefully examined; each fallen leaf and twig was picked up and all animals that could be seen were removed. All of this debris was also weighed. The surface was completely cleared of the layer of molding plant material and the loose soil on the surface was examined. A complete survey of one square meter in this manner took about five or six hours.

Eighteen small quadrats, 25 cm. square, were also studied. A frame was placed on the ground and all of the material enclosed was put into an aluminum can and taken to the laboratory, where it was weighed and examined, a small portion at a time, in a large tin pan.

In the case of all of the large quadrats, and most of the small ones, a sample of the leaf mold close to the quadrat was taken to the laboratory and after being weighed it was treated by the Berlese method. The material was placed in a large funnel, at the small end of which was a fine screen. At the upper end of the funnel were set three 40 watt carbon filament bulbs in a triple socket. The heat from this source gradually dried out the leaf mold, driving the animals down to the small end of the funnel and out into a vial of alcohol. The samples were treated in the funnel for six or seven hours. A longer treatment would have been desirable, but the electric light unit in use on the island could only be operated between 5 P. M. and 1 A. M. Because of the high humidity, it was impossible to use the Berlese apparatus effectively without heat. Only one Berlese sample could be handled each day, so in those cases where two of the 25 cm. quadrats were investigated in one day, a

Berlese analysis was carried out for only one of them. The can in which the sample was carried was rinsed out with alcohol to get those forms which might have adhered to the sides.

Berlese samples were taken for ten of the eleven large quadrats and for thirteen of the eighteen small ones. In the analysis which follows, except as otherwise noted, all quantitative studies are based on quadrats which were studied by both Berlese and manual collections.

In arriving at a figure for the number of animals present on a given quadrat, the number taken in the manual collections was used for all groups except the Acarina and Collembola. For these forms, whose small size made it impossible to collect all present on a quadrat, the results obtained by the Berlese funnel were used. The sample treated in the funnel was, presumably, comparable to that in the larger portion examined in detail by hand. Assuming that practically all of the Acarina and Collembola were driven out of the funnel by the heat, we had a figure for the total number present. Using this figure as a basis, the number of Acarina and Collembola in the main sample was determined. For example, on quadrat S-1 there were 244 grams of leaf mold. The sample used in the Berlese funnel weighed 84 grams. There was 2.9 times as much material in the main sample, so the number in the Berlese sample multiplied by 2.9 gave the number of Collembola and Acarina which would have been obtained had the entire quadrat been treated in the Berlese funnel.

A soil sample was taken for each quadrat and subsequently analyzed.*

The quadrats were taken at random at various places on the Island. The majority of them were within three or four hundred meters of the main laboratory buildings.

Rainfall was recorded by an automatic rainfall gauge located near the laboratory. Soil and air temperatures were recorded at intervals during the collection of each quadrat.

The material collected from each quadrat was placed in a vial containing 70 per cent alcohol. The Berlese and manual collections were kept separate. Upon returning to the university the animals were sorted into various taxonomic groups, with the aid of a binocular dissecting microscope. Some of the animals were colorless, others were dark colored, and the material was sorted over both a light and a dark background so that none of these forms would be missed. The animals were each measured, the smaller ones with the aid of an ocular micrometer and the larger ones with a steel ruler.

* The analysis was made by Dr. R. H. Bray of the University of Illinois.

In order to have sound taxonomic determinations, material was sent to specialists in the various groups wherever possible. In some cases there was no one available who could make determinations and in others reports have not yet been received. As a result, in some groups the determinations are to species and in others merely to family or order. Because the Neotropical fauna is poorly known in many of the invertebrate groups in question, even those sent to specialists are not all determined to species.

RESULTS

ENVIRONMENTAL FACTORS

The rainfall was recorded by an automatic rainfall gauge of the tipping bucket type and the daily record for the duration of the collections is given in Table 1. Relative humidity records were taken with a Lambrecht Recording Hygrometer, and temperature records were taken with a Taylor Recording Thermograph. The results are given in Tables 2 and 3. A comparison of the temperature and relative humidity values for the clearing and forest shows the marked effect of the forest on these two factors. The temperature in the forest is lower in the daytime and higher at night while the relative humidity is higher in the daytime and somewhat lower at night.

A comparison of the wet and dry weights of the soil samples gives an index of the moisture content of the litter. This information, expressed as the percentage of moisture in the total weight, is given in Table 4.

During the collections of the one-meter quadrats, the soil and air temperatures were recorded at intervals. The data for these readings are presented in Table 5. The differences between soil and air temperatures in the forest are somewhat comparable to those in the forest and clearing. The soil temperature is lower in the daytime and higher at night than the air temperature.

The results from the analysis of the soil samples have been tabulated in Table 6. Dr. Bray reports, "In general these samples and their tests are typical of the highly organic covering of some forest soils; lots of available K, Mg, and Ca, and very little acidity and with the N and PO_4 tied up in the organic matter."

Table 1. Rainfall (in inches)

Date		Midnight to 6 A.M.	6 A.M. to Noon	Noon to 6 P.M.	6 P.M. to Midnight
July	1	0	0	.01	0
	2	0	0	.17	0
	3	0	0	.15	.28
	4	.01	.01	.08	0
	5	1.05	0	0	0
	6	0	0	.32	.02
	7	0	0	.58	.02
	8	0	0	0	0
	9	0	0	.05	.06
	10	0	0	.20	.02
	11	0	0	.35	0.
	12	0	0	0	1.41
	13	.01	03	.27	.21
	14	0	.04	.05	0
	15	.01	0	.10	0
	16	.02	0	.19	0
	17	0	.21	.29	0
	18	0	.01	.53	0
	19	.03	.01	0	.05
	20	0	0	0	.03
	21	.01	.01	0	.02
	22	0	0	.41	.13
	23	.28	0	.12	.40
	24	0	.05	.09	0
	25	.01	.11	.54	0
	26	.01	.01	0	0
	27	0	.08	.26	.01
	28	0	0	0	0
	29	.06	0	0	0
	30	0	0	0	.02
	31	0	0	1.35	0
Aug.	1	0	0	0	0
	2	0	0	.25	.12
	3	.05	0	0	.08
	4	0	0	.73	.05
	5	.47	.01	0	.18
	6	.01	0	.01	.11
	7	.08	0	.56	.04
	8	0	.01	.15	.41
	9	0	0	.22	.09
	10	.04	.01	1.70	.31

Table 2. Relative Humidity (in per cent)

Clearing

Time	July 11	July 12	July 13	July 14	July 15	July 16	July 17
6 A.M.		96	100	100	100	100	100
12 Noon		76	80	80	78	76	80
6 P.M.	90	94	100	100	96	96	96
12 Mid.	96	100	100	100	100	100	100

Forest

Time	July 25	July 26	July 27	July 28	July 29	July 30	July 31
6 A.M.		98	96	97	97	97	98
12 Noon		96	96	98	97	98	98
6 P.M.	98	94	96	96	96	97	96
12 Mid.	98	96	98	98	96	97	97

Table 3. Temperature (degrees Fahrenheit)

Clearing

Time	July 11	July 12	July 13	July 14	July 15	July 16	July 17
6 A.M.		76	77	76	76	78	78
12 Noon		86	86	86	84	88	88
6 P.M.	78	82	76	78	78	78	78
12 Mid.	77	77	76	76	78	78	78

Forest

Time	July 25	July 26	July 27	July 28	July 29	July 30	July 31
6 A.M.		76	76	75	76	75	75
12 Noon		78	78	78	78	77	78
6 P.M.	78	78	76	78	77	77	78
12 Mid.	76	76	76	77	76	76	76

Table 4. Soil Moisture

Small Quadrats		Large Quadrats	
Quadrat No.	*Percentage H_2O*	*Quadrat No.*	*Percentage H_2O*
S- 8	52	2	44
S-10	64	3	41
S-12	56	4	33
S-13	65	7	48
S-15	56	8	51
S-16	54	9	48
S-17	46	10	68
S-18	41	11	69

Table 5. Soil and Air Temperatures in the Forest

Date		9 AM	10 AM	11 AM	12 N	1 PM	2 PM	3 PM	4 PM
July 9	Soil	75	76	76	76	76.5	76		
	Air	76.5	77	78	80	80	79.7		
July 12	Soil	77.5	77.5	77.5	77.5	78	78	78	76
	Air	79	79	79	79	80.2	79	79	78
July 13	Soil		74.8	76	76.5	75.8	75.8	76	76
	Air		76.5	78	78	74	74	73.5	73.5
July 14	Soil		77	77	77	77	77	77	
	Air		78	78.5	80.5	80	80.5	79	
July 15	Soil	77	77	77	77	77	77.5	77	
	Air	77	77.5	78.5	80	79	79.5	77	
July 17	Soil	77	77	77	77	77.5	78	78	78
	Air	78.5	79	79.2	80	80	81	81	76.5
July 18	Soil	77	76	76	76.8	76.8	76.8	76	76
	Air	76.5	77	78.3	78.2	78	76.8	76.5	76.5
July 19	Soil	78	78	78	77.5	78	78	77.5	77
	Air	77	78	74	74	75.5	76.5	77	77
July 31	Soil	77	77	77	77	77	78	78	78
	Air	76	76.5	77	79	80	80	79.6	79
Average	Soil	76.9	75.7	76.8	76.9	77	77.2	77.2	76.8
	Air	77.2	77.6	78.8	78.7	78.5	78.6	77.8	76.7

Table 6. Soil Analysis

Quadrat	K ppm*	NO_3 ppm*	Mg	Ca	SO_4	PO_4	pH	NH_3
1	300	1	Slight	500	0	Low	6.4	
2	300	1	Medium	475	0	Low	6.4	
3	350	0	High	375	0	Low	5.8	
4	175	0	Slight	400	0	Low	4.8	
5	500	0	High	500	0	Low	5.8	
6	325	0	High	500	0	Low	6.6	
7	750	2	High	500	0	Low	7.0	
8	800	0	High	500	0		6.0	
9	575	0	High	500	0	Low	4.7	
10	750	2	High	500	0	Slight	7.8	
11	530	0	High	400	0	Low	7.0	
S-3	850	0	High	400	0	Low	5.5	
S-6	625	0	High	>500	0	Low	7.0	
S-8	625	0	High	500	0	Low	6.8	
S-10	1500		High	>500	0	Slight	7.8	5
S-12	575		High	>500	0	Low	6.0	3
S-13	325		High	>500		Low	7.0	3
S-15	1225		High	>500		Low	6.6	4
S-16	375		High	>500		Low	7.0	2
S-17	400		High	>500		Low	5.8	3
S-18	750		High	>500		Low	7.0	0

* ppm = parts per million.

SYSTEMATIC ANALYSIS

A check list of the animals found in this study is presented in Table 7. Wherever possible, the animals were determined by specialists in the taxonomy of the group concerned. In some cases determination is to genus or species, while in others it is to family or order. The number of animals actually collected and identified during the course of this work was 11,233. There were representatives of 5 phyla, 12 classes, and 37 orders in the collections.

One of the most striking features of work in the Neotropical rain forest is the great number of new species which one finds. This is especially true for the habitat under consideration, as few people bother to collect among the dead leaves of the surface litter when there is so much to be seen and collected in other niches. Those forms which have been determined as new, by experts in the taxonomy of the group concerned, are starred in the check list. There were 67 new species, 20 new genera, and one new family, and there are undoubtedly at least as many more new species in the material which has not yet been determined.

Tables 8 and 9 present the data for the animals collected on each quadrat. All of the quadrats are presented. In the case of the quadrats for which there was a Berlese analysis, the figures include those forms taken in the Berlese funnel, as outlined in the section under methods. The quadrats not used in the main analysis are starred.

Table 7. Check list of animals present in collections.†

Phylum Platyhelminthes
  Class Turbellaria
    Order Alloeocoela
      Family Prorhynchidae
        Geocentrophora tropica Hyman*
    Order Tricladida
    Suborder Terricola
      Family Geoplanidae
        Geoplana cameliae Fuhrmann
        Geoplana panamensis Hyman*
        Geoplana aphalla Hyman*
      Family Rhynchodemidae
        Desmorhynchus angustus Hyman*
        Diporodemus plenus Hyman*
Phylum Nemathelminthes
  Class Nematoda
    Order Telogonia
    Suborder Ascaroidea
      Family Enoplidae
      Subfamily Trilobinae
        Mononchus sp.

† New species are indicated by (*), new genera by (**), and a new family by (***).

Subfamily Dorylaiminae
Dorylaimus sp.
Ironus sp.
Family Monhysteridae
Subfamily Monhysterinae
Monhystera sp.
Rotylenchus dihystera (Cobb, 1893)
Phylum Annelida
Class Oligochaeta
Class Hirudinea
Order Pharyngobdella
Family Herpobdellidae
Blanchardibdella decemoculata DeQual
Phylum Arthropoda
Class Crustacea
Order Isopoda
Family Oniscidae
Trichorhina isthmica Van Name
Trichoniscus (Clavigeroniscus) riquieri Arcangeli
Philoscia gatunensis Van Name
Philoscia (Ischioscia) variegata Dollfus
Scleropactes zeteki Van Name
Class Arachnida
Order Pedipalpida
Schizomus centralis Gertsch[1]
Order Scorpionida
Order Chelonethida
Order Phalangida
Family Phalangodidae 3 or 4 species
Family Gonyleptidae 1 species
Family Cosmetidae 1 or 2 species
Order Araneida
Family Dipluridae
Accola spinosa Petrunkevitch
Family Theraphosidae
Sericopelma rubronitens (Ausserer)
Family Ctenizidae
Idiops sp.
Ancylotrypa sp.
Family Ctenidae
Ctenus sp.
Cupiennius foliatus Cambridge
Family Heteropodidae
Tentabunda chickeringi Gertsch[1]
Olios sp.
Family Tetrablemmidae
Uniblemma unica Gertsch[1]
Family Zodariidae
Storena barroana Chamberlin
Family Argiopidae
Theridiosoma sp.
Mangora sp.
Eustala sp.
Aranea sp.
Pronous tuberculiferus Keyserling
Mimognatha foxi (McCook)
Family Linyphiidae
Bathyphantes plagiatus Banks

- Family Theridiidae
  - *Hubba insignis* Cambridge
  - *Stemmops* sp.
  - *Achaea acutiventer* Keyserling
  - *Euryopis* sp.
  - *Theridion indicatum* Banks
- Family Salticidae
- Family Oonopidae
  - *Oonopinus centralis* Gertsch*
  - *Scaphiella williamsi* Gertsch*
  - *Scaphiella barroana* Gertsch*
  - *Dysderina plena* Cambridge
- Family Caponiidae
  - *Nops maculata* Simon
- Family Pholcidae
  - *Metagonia caudata* Cambridge
  - *Modisimus dilutus* Gertsch*
  - *Pholcophorina zeteki* Gertsch
- Family Gnaphosidae
  - *Lygromma chamberlini* Gertsch*
- Family Clubionidae
  - *Myrmecotypus* sp.
  - *Castianeira* sp.
  - *Corinna* sp.
  - *Clubiona* sp.
- Family Anapidae
  - *Anapis keyserlingi* Gertsch*
  - *Anapistula minorata* Gertsch**
  - *Anapisona reclusa* Gertsch**

Order Acarina

- Family Bdellidae
  - *Eupalus* sp.
  - *Cunaxa* sp.
- Family Eupodidae
  - Genus ?
  - *Eupodes* sp.
  - *Bimichaelia* sp.
  - *Rhagidia* sp.
  - *Tydeus* sp.
- Family Trombidiidae
  - *Microtrombidium* sp.
  - Immature specimens
- Family Tetranychidae
  - Genus ?
  - Immature Specimens
  - *Raphignathus* sp.
- Family Uropodidae
  - Genus ?
- Family Parasitidae
  - Genus ?
  - Immature Specimens
  - *Podocinum* sp.
- Family Labidostommatidae
  - *Labidostomma* sp.
- Family Hoplodermatidae
  - *Mesoplophora* sp.
  - *Phthiracarus* sp.
- Family Oribatidae
  - Genus ?

Immature Specimens
Belba (= *Oribata*) sp.
Carabodes sp.
Eremulus (= *Eremaeus*) sp.
Galumna sp.
Globozetes sp.
Hermannella sp.
Heterochthonius sp.
Hypochthonius sp.
Lohmannia sp.
Malaconothrus sp.
Nothrus sp.
Oppia sp.
Oribatella sp.
Oribotritia sp.
Pseudotritia sp.
Rostrozetes sp.
Scheloribates sp.
Sphaerobates sp.
Sphaerocthonius sp.
Xylobates sp.
Zetes sp.
Family Tyroglyphidae
Histioma sp.
Class Pauropoda
Order Heterognatha
Family Pauropodidae
Pauropus panamensis Hilton*
Class Diplopoda
Subclass Pselapognatha
Family Polyxenidae
Barroxenus panamanus Chamberlin*[1]
Subclass Chilognatha
Order Limacomorpha
Family Glomeridesmidae
Glomeridesmus barricolens Chamberlin*
Glomeridesmus parvior Chamberlin[1]
Order Polydesmoidea
Suborder Polydesmidea
Family Stiodesmidae
Nabotomus delus Chamberlin**
Gasotomus dubius Chamberlin*
Dominicodesmus panamicus Chamberlin*
Family Stylodesmidae
Botryodesmus cryptus Chamberlin*
Family Oniscodesmidae
Oniscodesmus eutypus Chamberlin*
Barrodesmus isolatus Chamberlin**
Oncodesmus granosus (Gervais and Goudat)
Peltedo archimedes Chamberlin**
Family Eutynellidae[1]**
Eutynellus flavior Chamberlin**
Suborder Strongylosomatidae
Family Leptodesmidae
Typophallus evidens Chamberlin**
Desmacrides dichrus Chamberlin**
Tichodesmus micrus Chamberlin**
Family Sphaeriodesmidae
Sphaeriodesmus isolatus Chamberlin*

Order Nematomorpha
Suborder Stemmiulidea
Family Stemmiulidae
Stemmiulus canalis Chamberlin†
Order Juliformia
Suborder Spirobolidea
Family Spirobolidae
Rhinocricus williamsi Chamberlin†
Microspirobolus sp.
Suborder Spirostreptomorpha
Family Spirostreptidae
Orthoporus sp.
Order Platydesmiformia
Family Polyzoniidae
Siphonotus centralis Chamberlin*
Siphonotus angulifer Chamberlin*
Family Siphonophoridae
Siphonophora fallens Chamberlin
Class Chilopoda
Subclass Epimorpha
Order Geophilomorpha
Family Schendylidae
Schendylurus (Schendylotyn) integer Chamberlin
Family Ballophilidae
Diplethemus dux Chamberlin*
Lepynophilus mundus Chamberlin*†
Family Pachymerinidae
Polycricus fossor Chamberlin*
Family Chilenophilidae
Barrophilus isolatus Chamberlin**
Nabocodes mimellus Chamberlin*†
Order Scolpendromorpha
Family Cryptopidae
Newportia rogersi Pocock
Subclass Anamorpha
Order Scutigeromorpha
Family Scutigeridae
Psellioides sp.
Class Symphyla
Order Cephalostigma
Family Scutigerellidae
Scutigerella panama Hilton*
Family Scolpendrellidae
Symphiella panama Hilton*
Class Hexapoda
Order Thysanura
Family Lepismatidae
Grassiella sp. (juvenile)
Family Campodeidae
Lepidocampa juradii Silv.
Campodea biolleyi Silv.
Campodea batesoni Silv.
Family Japygidae
Japyx tristani Silv.
Parajapyx isabellae (Grassi)
Order Collembola
Order Orthoptera
Family Blattidae
Blaberus sp.

Order Isoptera
Heterotermes tenuis (Hagen)
Amitermes beaumonti Banks
Microcerotermes arboreus Emerson
Cylindrotermes macrognathus Snyder
Anoplotermes sp.
Nasutitermes (Uniformitermes) barrocoloradensis Snyder
Nasutitermes (N.) ephratae (Holmgren)
Order Neuroptera
Order Anoplura
Order Corrodentia
Family Psocidae
Order Thysanoptera
Terthrothrips clavivestris Hood
Order Homoptera
Suborder Auchenorrhyncha
Super-family Cercopoidea
Family Cercopidae nymphs
Super-family Fulgoroidea nymphs
Family Derbidae
Mysidia ? sp.
Family Fulgoridae
Subfamily Fulgorinidae nymphs
Family Achilidae nymphs
Family Flatidae
Ormenis roscida Germ. nymphs
Flatormenis sp. nymphs
Order Hemiptera
Family Cydnidae
Pangaeus sp.
Amnestus sp.
Family Aradidae
Artagerus sp.
Family Lygaeidae
Family Enicocephalidae
Family Reduviidae
Ectrichodia crudelis Stal
Rasahus sp.
Emesa sp.
Family Anthocoridae
Family Miridae
Family Cryptostemmatidae
Nannocoris sp.
Order Dermaptera
Family Labiduridae
Psalis sp.
Euborellia annulipes (Lucas)
Order Trichoptera
Family Hydroptilidae
Order Diptera
Family Psychodidae
Psychoda sp.
Family Ceratopogonidae
Culicoides diabolicus Hoff.
Family Culicidae
Anopheles sp.
Family Cecidomyidae
Family Stratiomyidae (larvae)
Family Tabanidae
Dichelocera analis Hine

Family Dolicopodidae
Paracleius obscurus V. D.
Family Phoridae
Puliciphora sp.
Chonocephalus sp.
Megaselia sp.
Family Drosophilidae
Drosophila sp.
Family Chloropidae
Oscinella sp.
Family Borboridae
Leptocera sp.
Order Coleoptera
Family Carabidae
Apenes five species
Masoreus sp.
Notobia umbrifera Bts.
Notobia sp.
Abaris darlingtoni Str.
Loxandrus two species
Loxandrus tetrastigma Bts.
Tachys two species
Genus ? near *Agonum*
Family Hydrophilidae
Phaenonotum sp.
Oosternum sp.
Genus ? near *Dactylosternum*
Family Silphidae
Aglyptinus sp.
Family Scaphidiidae
Scaphidium sp.
Genus ?
Family Scydmaenidae
Family Staphylinidae
Subfamily Oxytelinae
Subfamily Omaliinae
Subfamily Paederinae
Tribe Pinophilini
Tribe Paederini
Subfamily Staphylininae
Tribe Xantholinini
Tribe Staphylinini
Subfamily Tachyporinae
Tribe Tachyporini
Erchomus sp.
Subfamily Aleocharinae
Family Pselaphidae
Tribe Jubinini
Jubus terranus Park*
Jubus chickeringi Park*
Jubus turneri Park*
Barrojuba albertae Park**
Tribe Euplectini (*sensu latiore*)
Eurhexius zonalis Park*
Panarametia williamsi Park**
Tribe Batrisini
Arthmius (Arthmius) sabomba Park*
Tribe Tyrini
Juxtahamotopsis bardeni Park**

Family Lampyridae
    Silis sp.
    Silis sp. near *oblita* Gohr.
Family Dryopidae
    Parnus pusillus Sharp
Family Elateridae (larvae)
Family Dermestidae (larvae)
Family Dascylidae
    Ptilodactyla sp.
Family Histeridae
    Bacanius hamatus Lewis
    Epierus schmidti Wenzel and Dybas[1]
    Hister foveipygus Wenzel and Dybas[1]
    Phelister williamsi Wenzel and Dybas[1]
    Phelisteroides panamensis Wenzel and Dybas[1]
Family Nitidulidae
    Stelidota strigosa (Gyll.)
Family Endomychidae
    Micropsephodes sp.
    Genus ?
Family Coccinellidae
    Hyperaspis sp.
Family Ptiliidae
Family Tenebrionidae
    Anaedus, five species
    Genus ? three species
Family Cerambycidae (larva)
Family Curculionidae
    Phyllotrox sp.
    Anchonus sp.
    Eubulus sp.
    Conotrachelus sp.
    Palaeopus sp. apparently new
Subfamily Cossoninae
    New genus and species
Family Ipidae
    Pityophthorus sp. near *incompositus* Bldfd.
    Xyleborus propinquus Eichh.
    Xyleborus affinis Eichh.
    Coccotrypes sp.
    Stephanoderes sp.
Family Scarabaeidae
    Canthon angustatus Har.
    Canthon moniliatus Bates
    Canthon sallei Har.
    Uroxys sp. near *micros* Bates
    Choeridium aeneomicans Har.
    Canthidium sp.
    Phyllophaga sp.
    Ataenius, three species
Order Lepidoptera (larvae)
    Family Geometridae (larvae)
Order Hymenoptera
    Family Eulophidae
        Melittobia sp.
        Tetrasticus hagenowi (Ratz.)
    Family Calliceratidae
        Calliceras sp.
        Genus ?

Family Formicidae
Subfamily Dorylinae
Eciton (Labidus) coecum Latr.
Subfamily Ponerinae
Ectatomma ruidum Rog.
Alfaria panamensis Weber*
Discothyrea isthmica Weber*
Pachycondyla harpax (Fabr.)
Pachycondyla striata F. Smith
Termitopone laevigata (F. Smith)
Ponera sp.
Ponera sp. near *trigona*
Ponera parva Forel
Leptogenys (Lobopelta) n. sp. probably
Odontomachus chelifer Latr.
Odontomachus haematoda L.
Anochaetus sp. (not *mayri, inermis meinerti,* or *bispinosus*)
Neoponera apicalis Latr.
Subfamily Pseudomyrminae
Pseudomyrma sp.
Subfamily Myrmicinae
Pheidole sp. probably including one or two n. sp.
Solenopsis sp.
Megalomyrmex (Cepobroticus) wheeleri Weber
Megalomyrmex (Cepobroticus) symmetochus Wheeler
Crematogaster sp.
Aphaenogaster (Deromyrma) sp. near *phalangium* Emery
Wasmannia sp.
Leptothorax n. sp.
Rhopalothrix sp. near *equilatera* Weber
New dacetonine genus
Strumigenys brevicornis Mann
Strumigenys n. sp. near *S. emeryi* Mann and *fusca* Emery
Strumigenys n. sp.
Strumigenys eggersi Emery
Strumigenys tristani Menozzi
Cyphomyrmex rimosus Spinola
Cyphomyrmex costatus Mann
Sericomyrmex amabalis Wheeler
Trachymyrmex isthmicus Santschi
Trachymyrmex cornetyi Forel sp. *gatun* Weber
Trachymyrmex morgani Weber
Apterostigma mayri Forel
Cephalotes atratus (L.)
Subfamily Dolichoderinae
Azteca sp.
Subfamily Formicinae
Nylanderia steinheili (Forel)
Nylanderia sp.
Brachymyrmex n. sp.
Rhizomyrma n. sp.
Camponotus (Dinomyrmex) agra (F. Smith)
Camponotus (Myrmobrachys) sp.
Camponotus sp.
Phylum Mollusca
Class Gastropoda

Table 8. Small Quadrats—Record of Collections

	1	*2*	*3**	*4**	*5*	*6**	*7*	*8*	*9**	*10*	*11**	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*Total for Quadrats with Berlese*
Turbellaria	1		1		1					2	3		2						6
Nematoda	1	20		1	7	3	28	1		8		3	2	17		6		1	94
Oligochaeta	10	27	8	6	15	7	18	11	15	24	2	5	10	42	2	9	5	4	182
Hirudinea	1		1		3			1			1		2	3					10
Isopoda	34	33		3	32	15	4	5	9	21	9	6	18	6	9	8	8	4	188
Pedipalpida	3														2				5
Chelonethida	3	6	6	1	7	4	1	4	4	12	3	25	24	4	1	12		6	105
Phalangida	4	2	2	2				1	3	1	2				2	1		6	17
Araneida	6	6	5	4	1	1	3	2	5	8	3	8	9	3	1	2	1	3	53
Acarina	101	248	79	30	90	9	105	144	24	116	8	194	288	149	211	96	106	201	2049
Pauropoda		7	1	1	2			16	1	4		5	3			4	2		43
Diplopoda	20	13	13	4	20	9	5	24	11	12	6	13	17	10	9	10	3	18	174
Chilopoda		1		1						2			3	1	1		3	1	12
Symphyla	3				1				4			1	3	3		8	2		21
Thysanura	3	9	5	3	3	4		20	2	3	1	5	1	6	2	3	1	3	59
Collembola	102	228	7	8	51	5	30	124	10	180	8	219	624	270	154	236	127	239	2584
Orthoptera	1	5	1	2	1	2	1	4	2	2	2		1	1	3	1		4	24
Isoptera								4	10			7		3					14
Neuroptera larvae			1																
Anoplura		2								1									3
Thysanoptera						1													
Homoptera		1					2	4		4			2	4		4		1	22
Hemiptera	4	2	1		2	2	1	3	2	1	1		9	3	1		1	1	28
Dermaptera												1							1
Coleoptera larvae	14	7	11	1	10	2	1	4	6	6	2	3	12	8	5	3		4	77
Coleoptera adults	37	10	1	2	13	3	6	20	9	36		4	13	5	5	3	5	5	162
Lepidoptera larvae	1	1					2				1	2	2					1	9
Diptera larvae	4	10	4	1		8	5	5		9		1	7	3	1	4		1	50
Diptera adults		1	1		9	1	2			6	4			1	3	3		5	30
Hymenoptera larvae												1	1		1				3
Hymenoptera adults										1									1
Formicidae	67	290	170	2	185	10	133	28	55	526	22	168	156	77	14	160	3	11	1818
Insect larvae							1	1					1						3
Gastropoda	15	3	3	3	8	9	2	21	21	43	11	6	7	13	2	3	4	11	138
Total	435	932	321	75	461	95	350	447	193	1028	89	677	1217	632	429	576	271	530	7985

**No Berlese Analysis*

Table 9. Large Quadrats--Record of Collections

	1*	2	3	4	5	6	7	8	9	10	11	*Totals for Quadrats with Berlese*
Turbellaria	3	1	1	1		2	1	4		5		15
Nematoda		3		3	3		2			12	6	29
Oligochaeta	14	72	30	20	7	32	85	12	12	40	49	359
Hirudinea				1					3	3	1	8
Isopoda	25	17	68	46	44	64	70	47	122	123	42	643
Pedipalpida										1	1	2
Scorpionida						1						1
Chelonethida			15	47		28	17	35	30	32	4	208
Phalangida	8	10	11	24	57	33	5	9	8	27	2	186
Araneida	10	16	17	15	22	24	3	18	18	12	19	164
Acarina	20	29	124	450	424	677	578	1575	1440	1792	2142	9231
Pauropoda			22		23		18	34	120	32	119	368
Diplopoda	49	24	28	69	40	22	34	67	21	70	81	456
Chilopoda		1	2	16	3	27	4	1	2	3	8	67
Symphyla				15	22	3	3		1	31	7	82
Thysanura	2		7	77	67	28	33	2	60	8	120	402
Collembola	1	22	51	527	1204	902	770	1015	1950	4736	2975	14152
Orthoptera	2	3	9	10	3	6	8	8	12	7	12	78
Isoptera		1	11		1			1	6	22		42
Corrodentia						1			1			2
Anoplura				6								6
Thysanoptera larvae					3							3
Homoptera	1		1	2		1	1				7	12
Hemiptera	1	1	5	2	27	9	6	30	8	28	4	120
Dermaptera			3									3
Coleoptera larvae	5	11	6	7	3	10	9	14	7	48	8	123
Coleoptera adults	8	5	10	16	29	26	55	44	13	89	49	336
Lepidoptera larvae			3	1					1	7	1	13
Diptera larvae	7	13	9	5	3	4		4	6	41	42	127
Diptera adults	2		1	15	2	1	17	5	2	2	1	46
Hymenoptera pupae	2		1									1
Hymenoptera adults				10		1	10			2		23
Formicidae	129	88	117	388	245	367	108	49	600	384	8211	10557
Insect pupae					1							1
Insect larvae									1	9		10
Gastropoda	5	11	19	6	23	15	16	6	6	42	12	156
Total	294	328	571	1779	2256	2284	1853	2980	4450	7608	13923	38032

**No Berlese Analysis*

In the following section the various taxonomic groups are considered separately as regards their occurrence—indicated by the percentage of total number of quadrats on which representatives were found, and in regard to density—indicated by the percentage of the total population which the particular group represents. Other factors pertaining specifically to the individual groups are also considered.

Phylum Platyhelminthes

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	38	.08
Large quadrats	70	.04

The most common species was *Desmorhynchus angustus* Hyman, being present on 17 per cent of the small quadrats and 36 per cent of the large ones. In all there were six species present in the collections. Two orders and three families were represented.

The fact that only 38 per cent of the small quadrats contained planaria, while 70 per cent of the large ones did, is indicative of the relative scarcity of these forms. They must be considered as an important component of the litter fauna, but they apparently require a comparatively large area for subsistence.

Dr. L. H. Hyman who identified the planaria stated that most of the forms were not sexually mature. This may be an indication that the breeding takes place earlier in the year, perhaps at the start of the rainy season. On the other hand, it may mean that many of the adults do not carry over from year to year, and these forms were produced the previous year and would have matured and mated toward the end of the rainy season.

Phylum Nemathelminthes

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	85	.08
Large quadrats	60	1.18

Nematodes were found on a significant number of quadrats, but the number collected is probably not a true picture of their abundance. Collection by Berlese funnel is not satifactory for these forms and, because of their small size, a large proportion were probably missed in the manual

collections. It is also possible that the nematodes are more a part of the true soil fauna and their presence in the surface litter may be purely adventitious. Further work, in which adequate methods of collecting nematodes are employed, will be necessary before one can say just how important they are in the litter stratum.

The most commonly occurring as well as the most abundant group were *Dorylaimus* sp., as they were found on 85 per cent of the small quadrats and 60 per cent of the large. Four other genera were represented in the collections.

Phylum Annelida

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	2.40
Large quadrats	100	.95

Two classes of the phylum were present, the Oligochaeta and the Hirudinea. The former are more properly considered as soil forms and their presence in the litter is more or less by chance, as is suggested also for the Nemathelminthes. The Hirudinea may be considered as residents of the surface stratum.

Class Oligochaeta

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	2.27
Large quadrats	100	.93

I was unable to find anyone to determine the earthworms, so it is not possible to indicate any characteristic group.

Class Hirudinea

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	46	.13
Large quadrats	40	.02

The leeches were all of a single species, *Blanchardibdella decemoculata* De Qual. Dr. J. P. Moore, who identified them, stated that the gut of those sectioned contained the remains of small insect larvae. If this is indicative of the food of all these forms it would seem that the leech is

definitely a part of the floor stratum. The insect larvae are abundant there and, for a terrestrial form which requires a high humidity, the floor stratum would be the most favorable niche in the forest.

The species was described from Costa Rica and this is a new record of its occurrence. Dr. Moore found that although the specimens were sexually mature, they were considerably smaller than those from Costa Rica.

Phylum Arthropoda

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	94.61
Large quadrats	100	98.53

In the tropical rain forest the phylum Arthropoda reaches a peak of diversification and is by far the most characteristic and abundant phylum of the litter stratum. Seven of its classes and thirty-one of its orders were present in the collections. The representatives of this phylum so far out-number all other groups that one might consider the others insignificant.

The onychophoran, *Peripatus*, did not appear in any of the collections. This form, confined to the tropics, has been reported from Barro Colorado Island but in the last few years none have been collected. Some people claim that the ardor of collectors decreased the population to the vanishing point, but it is probable that *Peripatus* is still to be found on the island, even though it is not abundant.

Class Crustacea

Order Isopoda

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	2.35
Large quadrats	100	1.67

The order Isopoda was the only order of Crustacea represented in the collections. The most characteristic species was *Philoscia (Ischioscia) variegata* Dollfus, which was found on 100 per cent of the large and small quadrats. Another species of the same genus, *Philoscia gatunensis* Van Name, was found on 72 per cent of the small quadrats and 64 per cent of the large ones. It is interesting to note that four of the five species reported by Van Name (1926) were found, and one additional species was present. Van Name states that these species are entirely

native, forest-living species, that there are no introduced forms, and that this absence of introduced forms, "confirms the existence of purely natural ecological conditions."

The isopods were very much in evidence in all of the collections. An interesting behavior of some species was their ability to jump considerable distances, in much the same exasperating manner that is characteristic of collembola. Because of this habit, collection of all the forms present in the large quadrats was practically impossible, and to some extent this accounts for the difference in the population densities for the large and small quadrats.

Class Arachnida

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	27.85
Large quadrats	100	25.13

The Arachnida, mainly because of the great number of Acarina, are a very important component of the floor fauna. Six orders of this class were present in the collections.

Order Pedipalpida

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	15	.06
Large quadrats	20	.005

One species of the order Pedipalpida was found, *Schizomus centralis* Gertsch.

Order Scorpionida

One scorpion was found on one of the large quadrats.

Order Chelonethida

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	92	1.31
Large quadrats	80	.54

The pseudoscorpions are very small organisms which may be said to be characteristic of the litter, inasmuch as they occur in such a large proportion of the quadrats.

Order Phalangida

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	61	.21
Large quadrats	100	.48

Three families of harvestmen were present: Phalangodidae, Gonyleptidae, and Cosmetidae. The Phalangodidae were the most abundant, being found on 61 per cent of the small quadrats and 100 per cent of the large.

Order Araneida

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	.66
Large quadrats	100	10

Spiders were found in all of the quadrats, but as they are carnivorous in their feeding habits, it is not surprising that they form a small percentage of the total population. This does not lessen their importance as a major member of the community.

Seventeen families of the order Araneida were represented. The data on the occurrence of these families is given in Table 10. There is

Table 10. Occurrence of Families of Araneida

Family	*Percentage of Total Quadrats*	
	Small	Large
Dipluridae	8	0
Theraphosidae	15	50
Ctenizidae	15	10
Ctenidae	31	90
Heteropodidae	0	40
Tetrablemmidae	0	10
Zodariidae	30	50
Argiopidae	0	60
Linyphiidae	8	50
Theridiidae	0	40
Salticidae	8	30
Oonopidae	76	80
Caponiidae	15	10
Pholcidae	8	70
Gnaphosidae	0	30
Clubionidae	8	40
Anapidae	15	10

a considerable discrepancy between the values obtained for the large and small quadrats. This difference is in part due to the fact that the spiders tend to move about considerably and during the course of the four or five hours collecting of the material on the large quadrat there would be a movement of some of these forms into the area being studied. The family Oonopidae, in which the values for the large and small quadrats are comparable (76 and 80 per cent), was represented by rather minute species and in this case the movement would be confined to a relatively small range. Another, more important, reason is that the spiders are carnivorous and therefore tend to be less numerous than herbivorous forms. The smaller size of the 25 cm. quadrat would not be as likely to include spiders so the percentage of small quadrats including spiders would tend to be low. Many of the species were found only on the large quadrats, and then only one or two specimens were collected.

The most common species was *Oonopis centralis* Gertsch, found on 76 per cent of the small quadrats and 80 per cent of the large ones. Another common one was *Cupiennius foliatus* Cambridge, found on 30 per cent of the small and 90 per cent of the large quadrats.

Order Acarina

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	25.61
Large quadrats	100	24.00

The Acarina are one of the three dominant groups of arthropods present in the litter. They are a very important component of the fauna, forming an appreciable part of the base of the food chain. The results for both large and small quadrats are comparable in both percentage of the total population and percentage of the quadrats on which Acarina occurred.

The late Dr. A. P. Jacot had very kindly agreed to make the determinations of the Acarina. Due to his unfortunate death data are available for only twelve of the small quadrats. All of the information here will be based on these quadrats.

Ten families of mites were represented. The occurrence of the families, given as the percentage of the total number of quadrats on which they were found, is presented in Table 11.

Table 11. Occurrence of Families of Acarina

Families	*Percentage of Total Number of Quadrats*
Bdellidae	58
Eupodidae	74
Trombidiidae	25
Tetranychidae	58
Uropodidae	100
Parasitidae	100
Labidostommatidae	33
Hoplodermatidae	33
Oribatidae	100
Tyroglyphidae	33

The three families occurring on 100 per cent of the twelve quadrats, and a fourth on 74 per cent, Uropodidae, Parasitidae, Oribatidae, and Eupodidae respectively, may be considered as the characteristic families. The oribatids were the most numerous. The genera *Scheloribates* and *Sphaerobates* are the most characteristic of the family Oribatidae, being found on 80 per cent and 42 per cent of the quadrats respectively. Of the Eupodidae, the genus *Eupodes* occurred on 75 per cent of the quadrats, *Bimichaelia* on 58 per cent and *Tydeus* on 50 per cent. The genus *Podocinum* (Parasitidae) occurred on 58 per cent of the quadrats.

Class Pauropoda

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	61	.54
Large quadrats	70	.96

These small, colorless arthropods were represented by one species, *Pauropus panamensis* Hilton.

Class Diplopoda

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	2.18
Large quadrats	100	1.19

The millipeds are another very characteristic group, being found on all quadrats. They may also be considered important because they form a comparatively large percentage of the population. Six orders and thirteen families of Diplopoda were present. The data for these families are presented in Table 12.

Table 12. Occurrence of Families of Diplopoda

Family	*Percentage of Total Number of Quadrats*	
	Small	Large
Polyxenidae	38	50
Glomeridesmidae	23	50
Stiodesmidae	23	10
Stylodesmidae	7	0
Oniscodesmidae	76	50
Eutynellidae	46	60
Leptodesmidae	69	70
Sphaeriodesmidae	23	20
Stemmiulidae	53	50
Spirobolidae	23	30
Spirostreptidae	8	0
Polyzoniidae	0	10
Siphonophoridae	30	20

There is a rather close correlation between the small and large quadrats in this group, as opposed to the condition found in the Araneida. The millipeds are herbivorous and would not be limited as a carnivorous form might be. The families Leptodesmidae and Oniscodesmidae were represented by the greatest number of species and were found on the greatest percentage of the quadrats. The occurrence of the four most characteristic species is given in Table 13.

Table 13. Most Abundant Diplopod Species

Species	*Percentage of Total Number of Quadrats*	
	Small	Large
Barroxenus panamanus Chamberlin	38	50
Barrodesmus isolatus Chamberlin	38	40
Eutynellus flavior Chamberlin	46	60
Stemmiulus canalis Chamberlin	53	50

Class Chilopoda

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	54	.15
Large quadrats	100	.17

The centipedes are a carnivorous group and their distribution on the forest floor is similar to that described for the spiders. They form a small percentage of the total population and they did not occur on all of the small quadrats. There were 3 orders and 6 families present. The data for the families are presented in Table 14.

Table 14. Occurrence of Families of Chilopoda

Family	*Percentage of Total Number of Quadrats*	
	Small	Large
Cryptopidae	15	50
Scutigeridae	10	0
Schendylidae	8	0
Ballophilidae	0	40
Pachymerinidae	8	10
Chilenophilidae	31	40

No particular family stands out as a characteristic one. The most common species were not particularly widespread, as indicated in Table 15.

Table 15. Most Abundant Chilopod Species

Species	*Percentage of Total Number of Quadrats*	
	Small	Large
Barrophilus isolatus Chamberlin	31	30
Diplethemus dux Chamberlin	0	40
Newportia rogersi Pocock	15	50

Class Symphyla

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	61	.26
Large quadrats	70	.21

Two families of this class, represented by one species each, were found in the collections. It is interesting that in only one case were both species found on the same quadrat.

Class Hexapoda

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	61.11
Large quadrats	100	67.75

The class Hexapoda, due to the large numbers of Collembola and Formicidae, is the most important class of animals in the litter fauna; sixteen orders and fifty-four families were identified. The number of families would be higher if identification to at least this level had been possible in all groups.

Order Thysanura

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	92	.74
Large quadrats	90	1.05

Although the bristletails comprise a relatively small percentage of the total population, they can be considered as characteristic animals because they occur on such a large percentage of the quadrats. The most common species was *Japyx tristani* Silv., occurring on 67 per cent of the small quadrats and 45 per cent of the large. Almost as common, was *Lepidocampa juradii* Silv., on 55 per cent and 45 per cent of the small and large quadrats respectively.

Order Collembola

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	32.30
Large quadrats	100	36.80

The Collembola are the most abundant group of animals in the litter fauna. They are the most characteristic animals of the litter, if abundance and occurrence are taken as criteria of characteristic animals. They form the main base of the food chain and, as such, are very important in the general picture of the floor fauna.

Order Orthoptera

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	92	.30
Large quadrats	100	.20

The Orthoptera present on the quadrats were all nymphs except in the case of one adult roach (*Blaberus* sp.). These nymphs were almost all of the family Blattidae. The scarcity of adults would seem to indicate that breeding occurred either at the end of the rainy season and the nymphs collected were the offspring of the previous year's breeding, or that the breeding occurred just at the start of the rainy season.

Order Isoptera

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	31	.18
Large quadrats	60	.11

The scarcity of the termites in the forest floor litter was indeed a surprise. This group is very widespread in the tropics and forms a very important part of the fauna. In spite of the fact that each twig was carefully broken open and all woody material carefully examined, the number of termites found was very low. Further work on this particular problem is necessary before a satisfactory answer can be given. Allee (1926) in speaking of the fauna of rotten logs present on the forest floor at Barro Colorado Island says, "the large number of termites (present in rotten logs) emphasizes the fact that these insects are much more likely to be found in decaying wood than ranging free on the forest floor."

Of the seven species present, the most abundant was *Heterotermes tenuis* (Hagen). This species was found on 23 per cent of the small quadrats and 10 per cent of the large ones.

Order Neuroptera

One Neuroptera larva was found on one of the small quadrats.

Order Anoplura

Anoplura were found on 15 per cent of the small and 10 per cent of the large quadrats. These forms made up a very insignificant part of the total population (.04 and .03 per cent respectively).

Order Corrodentia

One member of the family Psocidae was found on each of two large quadrats. These forms were .005 per cent of the total population.

Order Thysanoptera

One adult thrip, *Terthropthrips clavivestris* Hood, was found on a small quadrat and three larvae were found on one large quadrat.

Order Homoptera

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	69	.27
Large quadrats	60	.03

There were five families of this order represented. Most of the specimens were nymphs. The most characteristic family was the Flattidae, being found on 33 per cent of the small quadrats and 20 per cent of the large ones.

Order Hemiptera

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	92	.35
Large quadrats	100	.31

The true bugs were well represented as far as occurrence on the two types of quadrats is concerned. There were eight families represented. A great many of the specimens were nymphs. The most characteristic family was the Lygaeidae with 69 per cent of the small and 70 per cent of the large quadrats having this group present. Two other groups, Cryptostemmatidae and Reduviidae, were well represented on the large quadrats, but not on the small. The former was present on 38 per cent of the small and 80 per cent of the large quadrats, while the latter was found on 23 per cent of the small quadrats and 70 per cent of the large ones.

Order Dermaptera

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	8	.01
Large quadrats	10	.005

Two species of earwigs were found, a single specimen of *Psalis* sp. on one small quadrat and three specimens of *Euborellia annulipes* (Lucas) on a large quadrat.

Order Trichoptera

One specimen of the family Hydroptilidae was found on a small quadrat.

Order Diptera (adults)

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	61	.37
Large quadrats	100	.12

Diptera adults formed a small portion of the total population, but they occurred on a significantly large percentage of the quadrats. Ten families were represented. The only family present on any appreciable number of quadrats was the family Psychodidae, represented by the genus *Psychoda* on 30 per cent of both the large and small quadrats.

Order Diptera (larvae)

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	92	.63
Large quadrats	100	.33

The Diptera larvae form a more important part of the litter fauna than do the adults. The larvae of only one family were identified, the family Stratiomyidae, and these forms were found on 53 per cent of the small and 60 per cent of the large quadrats.

Order Coleoptera (adults)

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	2.03
Large quadrats	100	.87

The Coleoptera are a characteristic group of animals of the litter. There were twenty-two families of this order present. Inasmuch as several of these families are rather important members of the litter fauna they will be considered separately.

Family Carabidae

The ground beetles were found on 23 per cent of the small and 70 per cent of the large quadrats. These carnivorous forms are wide ranging and relatively fast moving, and it is probable that the high percentage for the large quadrats is in part due to their wandering into the quadrat during the course of the collection. It is also true that these carnivorous forms must have a relatively large range and the chance of their occurring on the one-sixteenth of a square meter quadrat is not as great as that of their occurring on a meter quadrat. This same discrepancy is reflected in the occurrence of particular species; *e. g.*, *Notobia umbrifera* Bts. was found on 40 per cent of the large quadrats and not on any of the small ones. In like manner, *Loxandrus* "species 1 and 2" were each found on 30 per cent of the large quadrats and not on any small ones.

Family Hydrophilidae

Hydrophilids were found on 38 per cent of the small quadrats and 30 per cent of the large ones. A genus near *Dactylosternum* was found on 31 per cent of the small quadrats but not on any large ones.

Families Silphidae, Scaphidiidae, and Scydmaenidae

Family	OCCURRENCE *Percentage of Total Number of Quadrats* Small	Large
Silphidae	8	0
Scaphidiidae	15	0
Scydmaenidae	53	30

The Scydmaenidae are the only group to warrant special mention.

Family Staphylinidae

Staphylinids were present on 77 per cent of the small quadrats and 100 per cent of the large ones. They may be said to be characteristic Coleoptera of the litter fauna. Six sub-families were present. The Tachyporinae, genus *Erchomus,* were found on 80 per cent of the large and 23 per cent of the small quadrats. The Aleocharinae were present on 90 per cent of the large quadrats and 46 per cent of the small ones.

Families Pselaphidae, Lampyridae, Dryopidae, and Dascylidae

Family	OCCURRENCE *Percentage of Total Number of Quadrats* Small	Large
Pselaphidae	46	80
Lampyridae	0	8
Dryopidae	8	10
Dascylidae	0	10

The Pselaphidae were present on a large enough percentage of the quadrats to be considered as characteristic forms. Professor Park has kindly given me permission to use information which will appear in his forthcoming monograph of the Neotropical Pselaphidae. For the genus *Batrisodes,* closely related to some genera which occur on Barro Colorado Island, he states:

The food averages considerably less than a millimeter in length and appears to be the minute floor larvae and mold mites (Parasitidae, Gamasidae, Hoplodermatidae) of the forest floor. Consequently they compete with such small forms as *Atheta* (Staphylinidae) and many Scydmaenidae (*Euconnus cavipennis* Casey, *Connophron, Eumicrus*). Previous observations (Park, 1932) indicate that some pselaphids are scavengers as well, feeding on dead animals; and other data (Park, 1935) indicate that they may be cannibalistic, and also attack much larger game than mold mites, for example, earthworms.

For another species, *Tmesiphorus costalis* LeConte, which has allies in the Panama rain forest, Park states *(loc. cit.)*

. . . . *costalis* is a carnivore. It has been seen feeding upon the larvae of *Aphaenogaster fulva*, as well as the eggs and pupae of the host. In its more usual habitat away from the ant nests, the species has been seen to attack and eat mold mites (Hoplodermatidae) and minute flies *(Sciara)*.

Family Histeridae

There were five species of histerids in the collections. They occurred on 15 per cent of the small quadrats and 70 per cent of the large ones. *Phelister williamsi* Wenzel and Dybas was collected on 8 per cent of the small quadrats and 70 per cent of the large ones. We find here another group with many predacious members that shows a definite tendency to have a comparatively large range, therefore not occurring on as many of the small quadrats.

Families Nitidulidae, Endomychidae, and Coccinellidae

Family	OCCURRENCE *Percentage of Total Number of Quadrats* Small	 Large
Nitidulidae	0	20
Endomychidae	8	10
Coccinellidae	0	10

It is probable that these occurrences are purely adventitious and these families would not be considered as characteristic of the litter fauna.

Family Ptiliidae

These minute Coleoptera were found on 85 per cent of the small and 60 per cent of the large quadrats. One may consider them to be rather characteristic of the floor fauna.

Family Tenebrionidae

The tenebrionids were represented in 23 per cent of the small quadrats and 80 per cent of the large ones. The most characteristic forms were two species of an undetermined genus occurring on 40 per cent of the large quadrats and 8 per cent of the small ones. As the family was found on 80 per cent of the large quadrats, it is a characteristic family of the litter fauna.

Family Curculionidae

Weevils were found on 15 per cent of the small quadrats and 40 per cent of the large. This occurrence is not high enough to consider the family as characteristic. No particular group within the family was found on a significant percentage of the quadrats.

Family Ipidae

The Ipidae, another group of small beetles, were collected on 39 per cent of the small quadrats and 30 per cent of the large ones. These forms cannot be considered as characteristic of the floor fauna. The commonest representative of the family was *Xyleborus propinquus* Eichh., occurring on 31 per cent of the small and 20 per cent of the large quadrats.

Family Scarabaeidae

The scarabs were found on 15 per cent and 60 per cent of the small and large quadrats respectively. Although the figures are not very high, it seems that the family should be considered a characteristic one. These are comparatively large beetles, and it is likely that their small showing is due to the fact that all of the larger forms occur less abundantly than the smaller ones.

Summary of Coleoptera Adults

Table 16 gives those families of the order Coleoptera which, by reason of their occurrence on at least 60 per cent of the large quadrats, may be considered as characteristic of the litter fauna.

Table 16. Characteristic Families of Coleoptera

Family	OCCURRENCE *Percentage of Total Number of Quadrats* Small	Large
Carabidae	23	70
Staphylinidae	77	100
Pselaphidae	40	80
Histeridae	15	70
Ptiliidae	85	60
Tenebrionidae	23	80
Scarabaeidae	15	60

The most characteristic family of the order is the family Staphylinidae. The discrepancies between the occurrence on the large and small quadrats indicate that the large quadrats give a more adequate picture of the larger forms present. The smallest beetles, family Ptiliidae, were found on a greater number of small quadrats than large. This may be a result of the fact that the large quadrats were collected in the field and these very small forms might have been overlooked in some cases.

Order Coleoptera (larvae)

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	.96
Large quadrats	100	.32

The Coleoptera larvae are a significant part of the litter fauna. Determination to family was not possible in all cases, but Table 17 presents the data where identification was possible.

Table 17. Occurrence of Coleoptera Larvae

Family	*Percentage of Total Number of Quadrats*	
	Small	Large
Family undetermined	100	90
Carabidae	23	80
Hydrophilidae	8	10
Staphylinidae	62	50
Lampyridae	8	40
Tenebrionidae	0	30
Scarabaeidae	15	20
Elateridae	54	30
Dermestidae	15	0
Cerambycidae	0	20

The Carabidae, Staphylinidae, and perhaps the Elateridae might be considered as the most characteristic beetle larvae present.

Order Coleoptera (larvae and adults)

A consideration of the occurrence of some of the more characteristic families, in which the larvae and adults are placed together, accentuates the fact that they are really characteristic of the litter fauna. Three families are affected by such a treatment and the data are given in Table 18.

Table 18. Characteristic Coleoptera (larvae and adults)

Family	OCCURRENCE *Percentage of Total Number of Quadrats*	
	Small	Large
Carabidae	38	100
Staphylinidae	85	100
Scarabaeidae	31	60

Order Lepidoptera (larvae)

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	46	.11
Large quadrats	50	.03

The Lepidoptera, represented in the surface litter by larvae only, are not a particularly characteristic order. The family Geometridae was the only group determined, and it was found on 15 per cent of the small quadrats and 20 per cent of the large.

Order Hymenoptera

	OCCURRENCE *Percentage of Total Number of Quadrats*	DENSITY *Percentage of Total Population*
Small quadrats	100	22.78
Large quadrats	100	27.50

The order Hymenoptera is one of the three dominant groups present in the litter fauna. This dominance is due entirely to the ants, family Formicidae, as the other groups present are insignificant. In addition to the Formicidae, two other families were present, the Eulophidae and Calliceratidae.

Family Formicidae

Six subfamilies of ants were present, and each will be considered separately. The ants, a wide ranging and highly carnivorous group of animals, are of great importance in the food relationships of the forest floor. They prey upon all of the other arthropods of the stratum and in turn they are also a source of food for a great many animals. The stomach contents of *Bufo marinus* (L.), the giant toad which occurs on Barro Colorado Island, were studied by Weber (1938) in Trinidad and British Guiana. He found that a large part of the food of this toad was made up of ants. Many of the same species reported here were found in the toad stomachs. Albert Barden found that a lizard, *Basiliscus basiliscus* (L.), had 26.7 per cent ants in its food.

It is interesting that the percentage of occurrence of the various subfamilies in this study agrees with the abundance of these same subfamilies reported by Weber in the stomach analysis of *Bufo marinus* (L.). Such analyses may be rather important additions to the other quantitative methods, for those groups of animals which are likely to be eaten by the forms studied.

The Myrmicinae and Ponerinae may be considered as the characteristic subfamilies of ants. These two groups were found on the greatest percentage of quadrats and were represented by the greatest number of species, Myrmicinae being ahead of the Ponerinae in both respects.

Subfamily Dorylinae

Eciton (Labidus) coecum Latr., one of the army ants, was the only representative of this subfamily. It was found on only one small quadrat. This is not surprising, as the army ant colonies move about from place to place and would be abundant locally, but rather scarce over the entire area.

Subfamily Ponerinae

This group is the second most widespread subfamily of ants in the collections, occurring on 54 per cent of the small and 100 per cent of the large quadrats. The three most characteristic species, as shown by their high percentage of occurrence, especially in the large quadrats, are *Pachycondyla harpax* (Fabr.) and *Odontomachus haematoda* L., found on 70 per cent of the large and 8 per cent of the small quadrats, and *Anochaetus* sp., found on 60 per cent of the large and 15 per cent of the small quadrats. The other species were found on only one or two quadrats each.

Subfamily Pseudomyrminae

One representative of this subfamily, *Pseudomyrma* sp., was on one small quadrat.

Subfamily Myrmicinae

The Myrmicinae, found on 100 per cent of both the small and large quadrats, are the most common group of ants. The genus *Solenopsis* was the most characteristic as members of this genus were present on 92 per cent of the small and 90 per cent of the large quadrats. *Pheidole* was the next important genus, found on 69 per cent and 100 per cent of the small and large quadrats respectively. *Cyphomyrmex rimosus* Spinola occurred on 31 per cent of the small quadrats and 60 per cent of the large ones.

Subfamily Dolichoderinae

One large quadrat contained representatives of *Azteca* sp.

Subfamily Formicinae

This group was found on 15 per cent of the small and 40 per cent of the large quadrats. It would not be classed as a characteristic group on this basis. The species were scattered in distribution, no single one occurring on more than 10 or 15 per cent of the quadrats.

Phylum Mollusca

The Mollusca, all of the class Gastropoda, may be considered as characteristic forms of the floor fauna, as they occurred on all of the quadrats. The population densities were 1.04 per cent and .40 per cent for the small and large quadrats respectively.

DISCUSSION OF RESULTS

SUMMARY OF FAUNAL ANALYSIS

In the preceding section, each group has been considered in some detail and it seems advisable to point out some aspects of the fauna as a whole.

Faunal Percentages

The population density, as indicated by the percentage of the total population which a particular group represents, is given for the small and large quadrats for the main taxonomic divisions in Table 19 for the small and large quadrats.

Table 19. Faunal Percentages.

Group	*Percentage of Total Population*	
	Small Quadrats	Large Quadrats
Turbellaria	.08	.04
Nematoda	1.18	.08
Oligochaeta	2.27	.93
Hirudinea	.13	.02
Isopoda	2.35	1.67
Pedipalpida	.06	.005
Scorpionida		.003
Chelonethida	1.31	.54
Phalangida	.21	.48
Araneida	.66	.10
Acarina	25.61	24.00
Pauropoda	.54	.96
Diplopoda	2.18	1.19
Chilopoda	.15	.17
Symphyla	.26	.21
Thysanura	.74	1.05
Collembola	32.30	36.60
Orthoptera	.30	.20
Isoptera	.18	.11
Corrodentia		.005
Anoplura	.04	.02
Thysanoptera		.008
Homoptera	.27	.03
Hemiptera	.35	.31
Dermaptera	.01	.008
Coleoptera larvae	.96	.32
Coleoptera adults	2.03	.87
Lepidoptera larvae	.11	.03
Diptera larvae	.63	.33
Diptera adults	.37	.12
Hymenoptera	.05	.06
Formicidae	22.73	27.44
Gastropoda	1.73	.40

Because a great portion of the population is made up of three groups of animals, the Collembola, Acarina, and Formicidae, the relationships in the other groups are somewhat obscured. In order to show these relationships more clearly, the three groups mentioned have been treated as single units and all of the other animals have been lumped in a fourth. The data are presented in Table 20. The fourth group was then treated as a separate unit and the population percentages calculated, after the Acarina, Collembola, and Formicidae had been removed. These data are found in Table 21.

Table 20. Faunal Percentages

Group	*Percentage of Total Population*	
	Small Quadrats	Large Quadrats
Acarina	25.61	24.00
Collembola	32.30	36.80
Formicidae	22.73	27.44
All others	19.36	11.76

Table 21. Faunal Percentages
(Excluding Acarina, Collembola, and Formicidae)

Group	*Percentage of Total Population*	
	Small Quadrats	Large Quadrats
Turbellaria	.39	.37
Nematoda	5.81	.71
Oligochaeta	11.83	8.76
Hirudinea	.65	.20
Isopoda	12.22	15.69
Pedipalpida	.33	.05
Scorpionida		.02
Chelonethida	6.83	5.08
Phalangida	1.11	4.54
Araneida	3.45	4.00
Pauropoda	2.80	8.98
Diplopoda	11.31	11.13
Chilopoda	78	1.63
Symphyla	1.37	2.00
Thysanura	3.84	9.81
Orthoptera	1.56	1.90
Isoptera	.91	1.00
Corrodentia		.05
Anoplura	.20	.15
Thysanoptera		.07
Homoptera	1.43	.29
Hemiptera	1.82	2.93
Dermaptera	.07	.07
Coleoptera larvae	5.00	3.00
Coleoptera adults	10.53	8.20
Lepidoptera larvae	.59	.32
Diptera larvae	3.25	3.01
Diptera adults	1.95	1.12
Hymenoptera	.26	.59
Gastropoda	8.97	3.81

Occurrence

The percentage of the quadrats containing representatives of a given group is another index of a characteristic group. It is not necessary for a group to be present in great numbers before it is considered characteristic. If only a few examples are found on each quadrat, it can be considered more than chance. One would therefore expect to find the order represented in any sample one might take. Table 22 contains the data for the occurrence of the main taxonomic groups.

Table 22. Occurrence of Main Taxonomic Groups

Group	*Percentage of Total Number of Quadrats*	
	Small	Large
Turbellaria	38	70
Nematoda	85	60
Oligochaeta	100	100
Hirudinea	46	40
Isopoda	100	100
Pedipalpida	15	20
Scorpionida		10
Chelonethida	92	80
Phalangida	61	100
Araneida	100	100
Acarina	100	100
Pauropoda	61	70
Diplopoda	100	100
Chilopoda	54	100
Symphyla	61	70
Thysanura	92	90
Collembola	100	100
Orthoptera	92	100
Isoptera	31	60
Corrodentia		20
Anoplura	15	10
Thysanoptera	8	10
Homoptera	69	60
Hemiptera	92	100
Dermaptera	8	10
Coleoptera larvae	100	100
Coleoptera adults	100	100
Lepidoptera larvae	46	50
Diptera larvae	92	100
Diptera adults	61	100
Hymenoptera	15	40
Formicidae	100	100
Gastropoda	100	100

Raunkiaer Analysis

Raunkiaer (1918), a European worker, devised an interesting method of analysis which gives the index species of a community or any portion of a community. The number of quadrats upon which a given species is found is the frequency index and the percentage of occurrence is the frequency percentage. The frequency percentages are thrown into five

classes: I, 1 to 20 per cent; II, 21 to 40 per cent; III, 41 to 60 per cent; IV, 61 to 80 per cent; and V, 81 to 100 per cent. When these data are graphed, one obtains a typical curve, which is usually found in similar studies of any natural population. The data for both the small and large quadrats were treated in this manner and may be found in Table 23 and the graphs in Figures 1 and 2.

Table 23. Raunkiaer Analysis
Distribution of the Frequency Percentages

Group	Class I		Class II		Class III		Class IV		Class V	
	S	*L*	*S*	*L*	*S*	*L*	*S*	*L*	*S*	*L*
Turbellaria	3	1	2	3	0	0	0	0	0	0
Nematoda	4	1	0	1	0	0	0	1	1	0
Hirudinea	0	0	0	0	1	1	0	0	0	0
Isopoda	1	1	0	2	1	0	0	2	2	1
Araneida	14	20	2	12	0	6	1	1	0	1
Pauropoda	0	0	1	0	0	0	0	1	0	0
Diplopoda	4	3	9	7	2	5	1	1	0	0
Chilopoda	3	4	1	1	0	2	0	0	0	0
Symphyla	0	0	2	1	0	1	0	0	0	0
Isoptera	2	4	1	1	0	0	0	0	0	0
Coleoptera	23	32	4	10	0	3	0	1	0	1
Formicidae	22	17	4	9	0	3	1	4	1	2
Totals	76	83	26	47	4	21	3	11	4	5

S - Small Quadrats
L - Large Quadrats

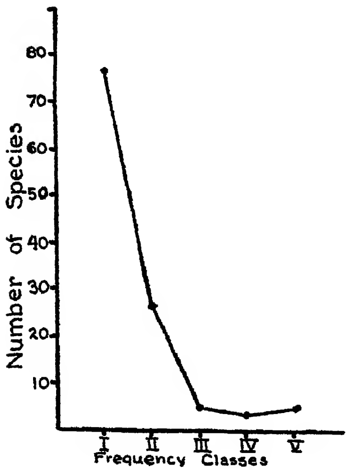

Fig. 1. Raunkiaer analysis - small quadrats

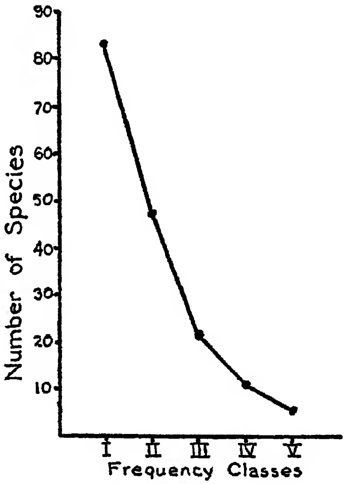

Fig. 2. Raukiaer analysis - large quadrats

The index species, those that fall in Class V, are: *Dorylaimus* sp. (Nematoda), *Philoscia gatunensis* Van Name and *Philoscia variegata* Dollfus (Isopoda), *Cupiennius foliatus* Cambridge (Araneida), *Erchomus* sp. (Staphylinidae), *Pheidole* sp. and *Solenopsis* sp. (Formicidae).

The graphs show an interesting character of any natural population. Most of the species are found at random and rather infrequently over a given area. Only a very small percentage of the species occurs in considerable numbers and in any part of the region studied. The so-called index species, those that are found throughout the area, seem to be the best adapted to their particular habitat. The index species may be slightly better adjusted to one particular phase of the environment and this slight advantage over the other closely related forms enables them to occupy a large portion of the territory. The fact that there are only seven index species, representing five orders, indicates that the remaining species are probably about equally balanced in their adjustments and competition between species limits the number which can inhabit the area.

Characteristic Groups

It is not possible to designate a truly dominant group of forest litter animals, in accordance with the definition of dominance given by Shelford and Clements (1939). In this more or less sheltered habitat none of the animals may be said to receive the full impact of the environment. In fact, it would be difficult to pick out any animal in the tropical rain forest and call it a dominant. The plants, mainly the large trees, are the only true dominant living forms. It appears that we are justified, however, in speaking of certain groups of animals as characteristic of the litter fauna.

It has been pointed out that certain forms are found on a large percentage of the large quadrats and on a smaller percentage of the small ones. The suggestion was made that the carnivores and larger herbivores, requiring a relatively large range, would not necessarily be collected on any one small quadrat, but would appear on a significant portion of the large ones.

On the basis either of large population density and/or occurrence on at least 70 per cent of the large or small quadrats, those groups considered to be characteristic of the litter fauna are presented in Table 24.

Number of Species

It has already been mentioned that in the tropics in general the number of species present is large and the number of individuals of each species is correspondingly lowered. In spite of the fact that determination in many cases could not be obtained, there were 294 different

Table 24. Characteristic Groups of the Litter Fauna

Group	*Percentage Occurrence*		*Percentage of Total Population*	
	Small	Large	Small	Large
Turbellaria	33	70	.08	.04
Nematoda	85	60	1.18	.08
Oligochaeta	100	100	2.27	.93
Isopoda	100	100	2.35	1.67
Chelonethida	92	80	1.31	.54
Phalangida	61	100	.21	.48
Araneida	100	100	.66	.10
Acarina	100	100	25.61	24.00
Pauropoda	61	70	.54	.96
Diplopoda	100	100	2.18	1.19
Chilopoda	54	100	.15	.17
Symphyla	61	70	.26	21
Thysanura	92	90	.74	1.05
Collembola	100	100	32.30	36.80
Orthoptera	92	100	.30	.20
Hemiptera	92	100	.35	.31
Diptera adults	61	100	.37	.12
Diptera larvae	92	100	.63	.33
Coleoptera adults	100	100	2.03	.87
Coleoptera larvae	100	100	.96	.32
Formicidae	100	100	22.73	27.44
Gastropoda	100	100	1.73	.40

species, determined either to species or to genus. In contrast, Dr. Elizabeth Lunn in a study of the fauna of the leaf mold in a forest near Evanston, Illinois (1939) found 111 different species. The difference is all the more striking because practically all of her material was determined to species. In the case of this material, there are at least 100 more species which can be added to the total when all of the determinations are available.

This large number of species in the tropics may be in part due to the great abundance of food of various kinds and the wide variety of habitat niches. Evolutionary tendencies which lead a particular group to become associated with a particular habitat niche or food would have a definite survival value, especially if it were a food or habitat for which there was little competition. The great variety of these two factors, food and habitat, may possibly be an important item in the development of the great variety of species present.

QUANTITATIVE ASPECTS OF THE PROBLEM

The number of animals present in the litter of the Panama rain forest floor is perhaps best illustrated by Figure 3. This figure shows the average number of animals of each group found on one-tenth of a square meter. The animals have been drawn to scale, the size for each group being the average size of all those collected. The animals in their natural

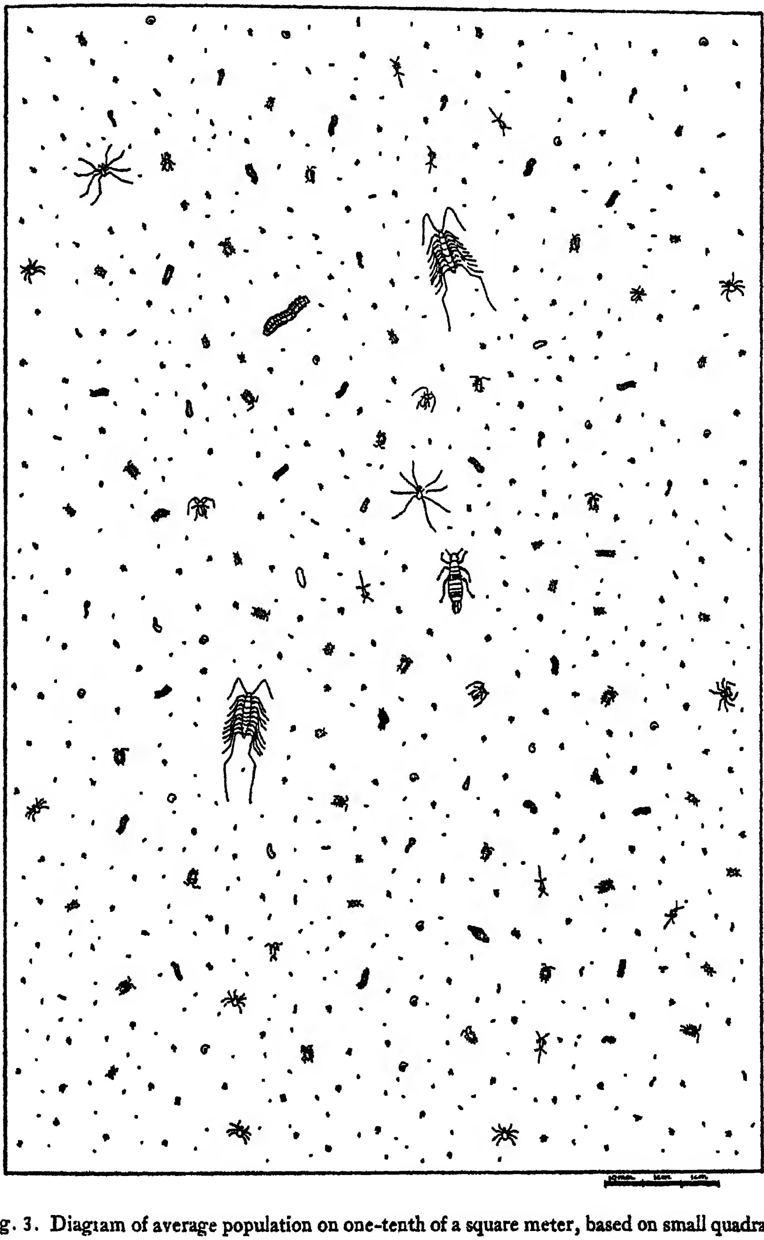

Fig. 3. Diagıam of average population on one-tenth of a square meter, based on small quadrats.

habitat are of course not on a single plane, but are distributed throughout the leaf mold which may be from two to five inches thick. The very small circles indicate the Acarina, and the Collembola are represented by small circles with a line drawn out to indicate the furcula. Other forms are stylized and are large enough to be recognized.

Number per Square Meter

Based on the small quadrats, there was an average of 9,822 animals per square meter. This amounts to approximately 40,000,000 per acre. The average for the large quadrats is somewhat lower, 3,803 per square meter, or about 15,500,000 per acre. The highest value for any one small quadrat was 19,472 per square meter (79,000,000 per acre) and the highest value for a large quadrat was 13,923 per square meter (56, 000,000 per acre).

Biomass

Lunn (1939) determined the biomass (Pickles, 1937) by weighing the more common animals found in her study of the leaf and log mold of Carlé Woods, Des Plaines, Illinois. She found that there were 33.35 pounds of microarthropods and oligochaetes per acre of forest floor (leaf mold). Facilities were not available for making accurate measurements of the weights for the animals in this study, so the figures given by Dr. Lunn in her work are used. These figures are given in Table 25.

Table 25. Approximate Average Weight in Grams of Forest Floor Animals (From Lunn, 1939)

	Grams
Oligochaeta	.002
Coleoptera larvae	.02
Coleoptera adults	.03
Diptera larvae	.002
Trachelipus rathkei (an Isopod)	.03
Collembola	.000025
Acarina	.000025

On the basis of these figures there were 15.53 grams present on each square meter, or 138 pounds per acre. This figure is merely an approximation and it is based on the assumption that on the average the weights for the particular groups are comparable. The true figure would be considerably higher, as the great number of ants and all of the other minor groups were not included. In fact, these results based on the small quadrats include only 6,509 of the 9,822 animals on a square meter (67 per cent). The mass of available food material is shown to be very appreciable and a more comprehensive study of this problem of the biomass is desirable.

Eltonian Pyramid

In dealing with the number of animals present in a given community, the fact that the greatest number of animals is found in the smallest size range is very evident. Charles Elton (1936) has been a leading student of animal populations. He devised a method of expressing this relationship of numbers and size, the so-called Eltonian Pyramid. The number of animals present is plotted against their size. The data for the small quadrats have been treated in this manner and the resulting pyramid may be found in Figure 4. The data upon which this figure is based are in Table 26. The sizes used are the average sizes for all of the members of the group found in the collections.

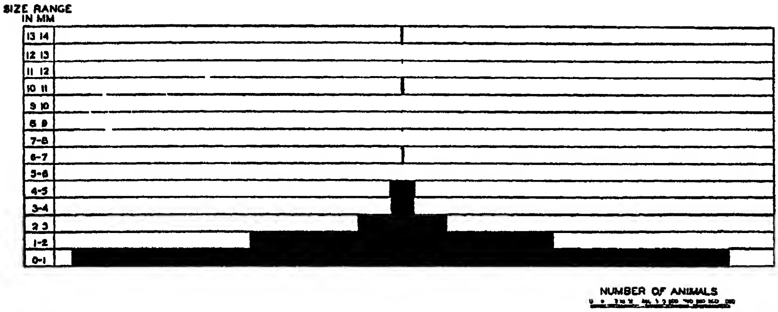

Fig 4. Eltonian pyramid of numbers, based on small quadrats.

The bearing of this problem on the food relations of the forest floor is fairly obvious. The basis of the food for all animals is the plant matrix. We find the minute Collembola and Acarina forming the broad base of the pyramid, and in general these forms are herbivorous. As we move toward the apex of the pyramid, we find the carnivorous forms present in smaller numbers. In general, one may say that the carnivorous animals are larger and are present in smaller numbers than the herbivorous forms upon which they feed. Carnivores also feed upon other carnivores and upon scavengers, and the prey is usually smaller than the predator. This latter condition, however, does not hold true for the ants. The Formicidae, falling in the 1 to 2 mm. size range, are present in large numbers and they are carnivorous for the most part. Because of their closely integrated social organization, a great many ants may attack a much larger animal and, while the size of any single ant is insignificant, in the aggregate their "size" is tremendous. Under certain conditions, organisms thousands of times the size of an individual ant may be the victim of the ants collectively.

Table 26. Data for Eltonian Pyramid (small quadrats)

Size range	*No. on 13 small quadrats*
0 - 1 mm.	
Acarina	2049
Nematoda	94
Pauropoda	43
Collembola	2584
1 - 2 mm.	
Chelonethida	105
Anoplura	3
Homoptera	22
Diptera adults	30
Formicidae	1818
Insect larvae	3
Araneida	53
Symphyla	21
Hymenoptera	4
Gastropoda	138
2 - 3 mm.	
Oligochaeta	182
Pedipalpida	5
Phalangida	17
Hemiptera	28
Coleoptera adults	162
Isopoda	188
Thysanura	59
3 - 4 mm.	
Coleoptera larvae	77
Diptera larvae	50
Orthoptera	24
Isoptera	14
4 - 5 mm.	
Diplopoda	174
Turbellaria	6
6 - 7 mm.	
Hirudinea	10
10 - 11 mm.	
Chilopoda	12
13 - 14 mm.	
Dermaptera	1
Lepidoptera larvae	9

Very little is known about the food habits of organisms living in the forest floor litter. When it comes to those of the tropical rain forest litter, nothing is known specifically. Although some broad generalizations can be made in regard to possible food relations, further study is necessary before any definite statement about the food chain is possible.

RELATION OF THE FAUNA TO ENVIRONMENTAL FACTORS

Physical Factors

Soil Analysis. The data for the soil analysis have been presented in Table 6. Of the factors determined, the only ones which varied significantly were the hydrogen ion concentration (pH) and potassium (K).

The number of animals present does not seem to be correlated with the K content of the soil. Figures 5 and 6 show the number of animals

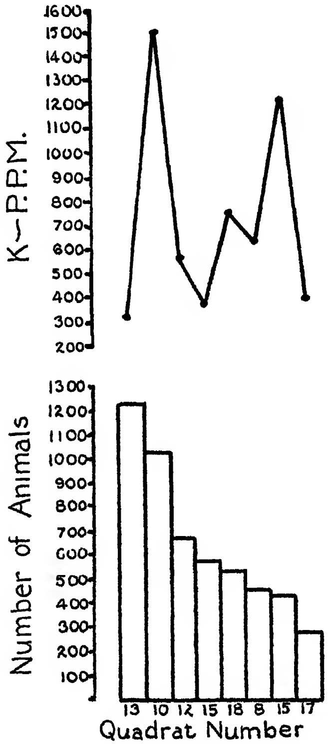

Fig. 5. Relationship between the number of animals present and the potassium content of the soil - small quadrats.

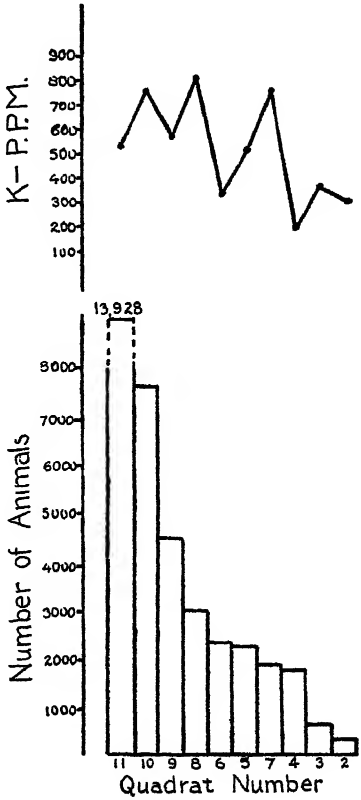

Fig. 6. Relationship between the number of animals present and the potassium content of the soil - large quadrats.

present in the lower portion and the variation in K is plotted above. In the case of the small quadrats the lowest value for K was found on the quadrat containing the most animals, while the highest value was found on the quadrat with the second greatest number of animals. In the large quadrats, likewise, there is no apparent correlation between the K content of the soil and the number of animals present.

The pH in relation to the number of animals present is graphically shown in Figures 7 and 8. There is a mere suggestion, especially in the small quadrats, that high population values are associated with a neutral condition, but it is no more than a suggestion.

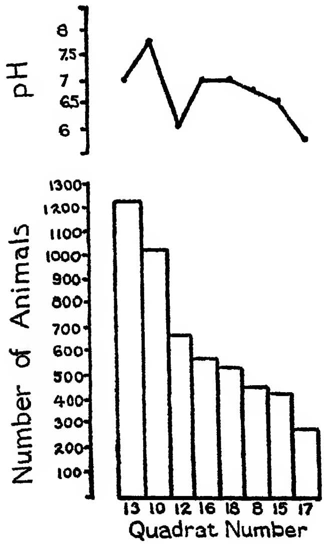

Fig. 7. Relationship between the number of animals present and the hydrogen ion concentration of the soil - small quadrats.

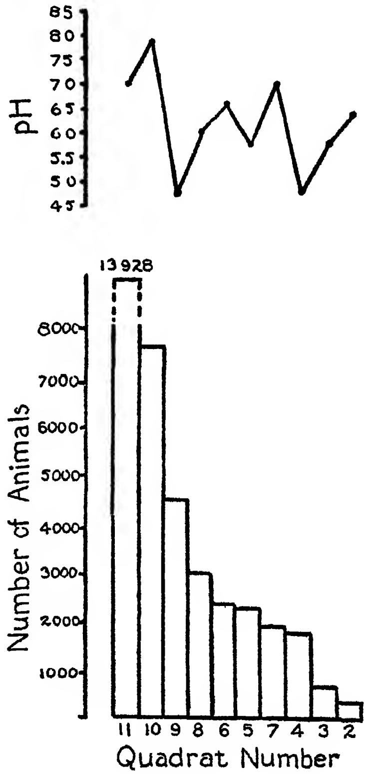

Fig. 8 Relationship between the number of animals present and the hydrogen ion concentration of the soil - large quadrats.

Soil Moisture. The soil moisture values, presented in Table 5, have been plotted above the histograms for population density in Figures 9 and 10. There seems to be some correlation between the number of animals present and the soil moisture. The soil moisture is indicative of the conditions in the leaf mold. It is probable that the minute forms, with with their thin body walls, require a very high moisture. Lunn (1939) found that Acarina moved to the chamber with the highest humidity

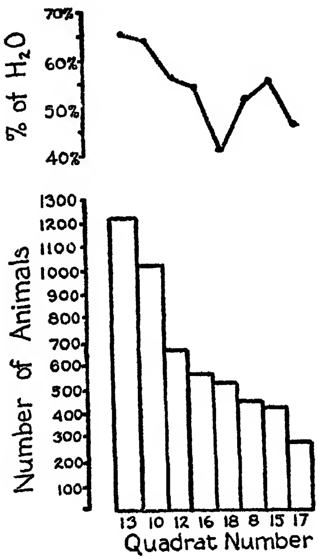

Fig. 9. Relationship between the number of animals present and the water content of the soil - small quadrats.

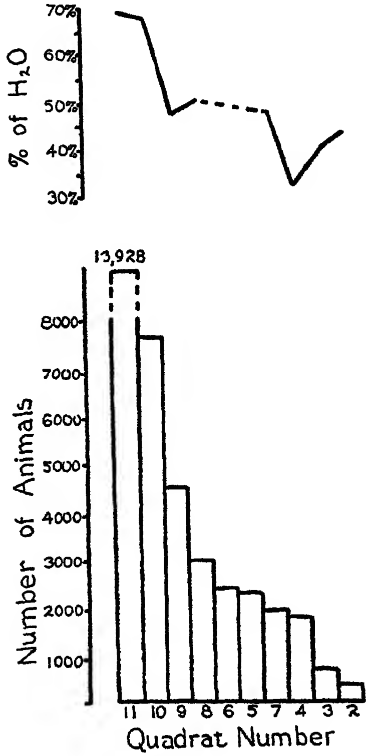

Fig. 10. Relationship between the number of animals present and the water content of the soil - large quadrats.

when placed in a gradient. Ford (1938) found that Collembola moved to the base of grass clumps when it was dry and under more humid conditions they were found on the grass itself. In those quadrats with low moisture values, these minute forms may move into the soil, as the moisture there would be higher than in the leaf mold.

Rainfall. In view of the apparent tendency for the population density to be related to the moisture, it seemed advisable to determine whether or not there was any fluctuation in population correlated with rainfall. (The rainfall record for the period of study is given in Table 1). There was no apparent direct correlation between the number of animals present and the rainfall. A comparison of the population densities with the amount of rainfall in the six hours preceding collection gave negative results, (Figure 11). A similar comparison for 1, 2, 3, 4, and 5 hours

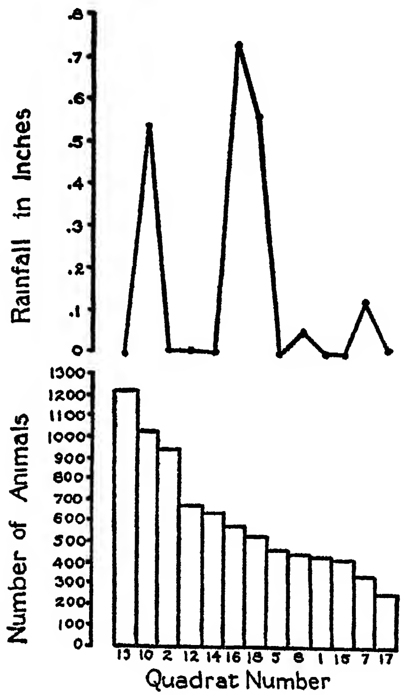

Fig. 11. Relationship between the number of animals present and the amount of rainfall in the six hours preceding time of collection - small quadrats.

preceding collection also gave negative results. The forest canopy offers such a large surface that the amount of rain falling to the floor is considerably less than that falling in the open where the rainfall measurements were made. The force of its fall is also broken and in many cases the drops are broken up to give more of a mist on the forest floor itself.

Biotic Factors

Amount of Leaf Mold. One would expect that the number of animals present would vary to some extent with the amount of leaf mold. The amount of leaf mold (in grams) has been plotted above the histograms for population density in Figures 12 and 13. The small quadrats show this trend very well, especially when it is noted that there were several large pieces of bark on quadrat 15, and not very much leaf mold. The trend is also evident in the large quadrats, but is not as well defined. It cannot be said that the amount of leaf mold, above a certain minimum, is a direct factor in controlling the abundance of organisms, but it is a

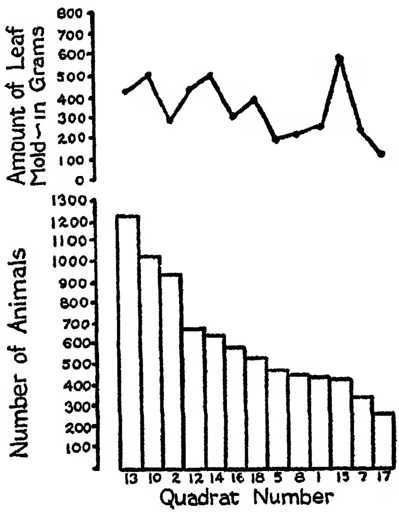

Fig. 12. Relationship between the number of animals present and the amount of leaf mold - small quadrats.

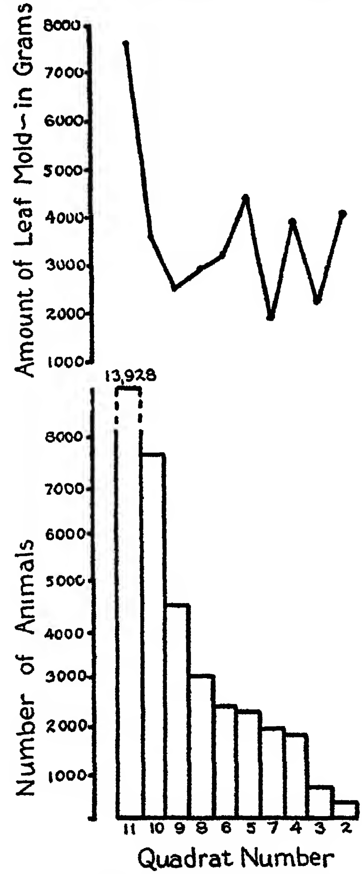

Fig. 13. Relationship between the number of animals present and the amount of leaf mold - large quadrats.

factor which has at least an indirect effect. Within certain limits it is probably not an important factor, but very little mold and large quantities of it must be considered as factors in control of the number of organisms.

Army Ants. The army ants constitute the only predator factor which could be correlated with population densities. The raiding columns of these ants pass through a given area and capture or drive out a large portion of the animal life. In two cases there was definite evidence that army ants had raided the area the day before collection. In both cases the population density was at a minimum, and it may be that low values in other instances are due to the same cause.

Population Fluctuations

Diurnal. The large quadrats were all collected in the daytime, and collection usually took from 9 A.M. to 3 or 4 P.M. The small quadrats were taken at various times during the day. A study of the population densities did not show any fluctuation that could be correlated with the time of collection.

Nocturnal. Two quadrats, S-4 and S-6, were collected at night. They were taken at 11 P.M. and 10 P.M. respectively. It was not possible to obtain a Berlese analysis for these two quadrats; they were kept over-night in an aluminum can and sorted out the following morning. The values for these two quadrats are low—75 and 95 animals. The average value for the other small quadrats, exclusive of those forms taken in the Berlese analysis, is 209. With only two quadrats taken at night, one cannot draw any conclusions, but they both gave low values and further study may show some difference in the number of forms present at night. There are two possible explanations for the condition, either the animals retreat into the soil, or they move up into the trees and shrubs (Park, Lockett, and Myers, 1931, and Park and Strohecker, 1936).

Seasonal. In Figure 14 the number of animals collected is plotted against the date of collection. The gradual increase in number of forms found on the large quadrats may be due to two causes. To some extent there was an improvement in collection technique for the first few quadrats, but this does not appear to be the only reason for the gradual rise. The results for the large quadrat on July 19 and the first small quadrat on July 20 are strictly comparable and they indicate that the methods may be comparable throughout. A suggestion regarding this fluctuation may be in order. During the dry season, from January through April, the rainfall is very low and a large number of forms probably do not survive. This season of the year may be compared to the winter of temperate zones. With the onset of the rainy season in

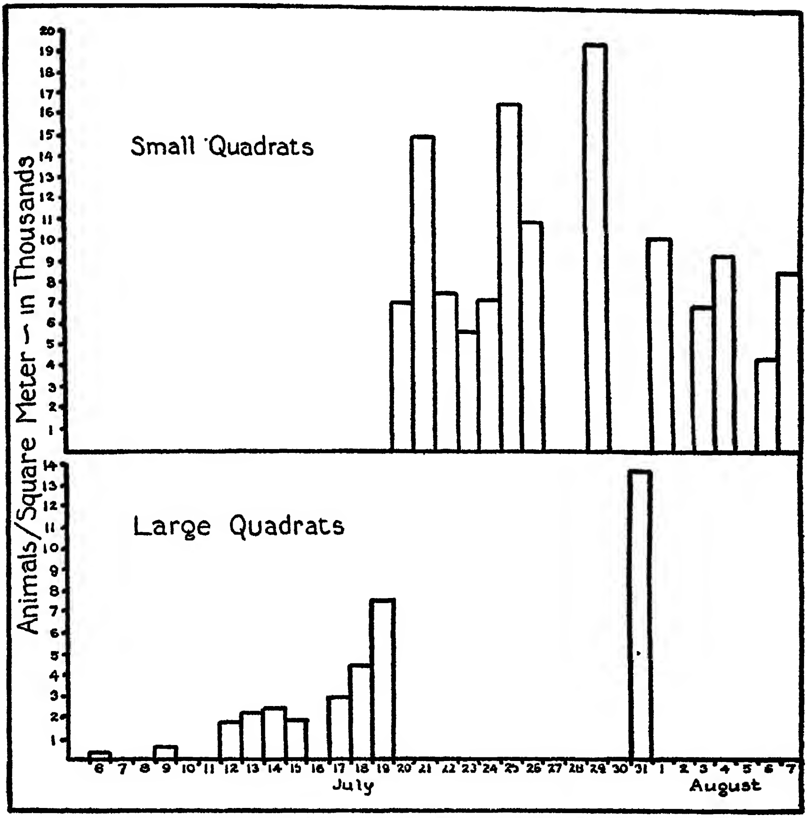

Fig. 14. Relationship between the number of animals present and the date of collection - small and large quadrats.

May, life in the litter begins with renewed vigor and those forms which have survived the dry season commence to reproduce. There would be a certain amount of lag in the population growth and not until the early part of July would the population begin to rise appreciably. This is the time when the collections reported here were commenced. It has been shown above that there was some correlation between the soil moisture and the population density. The earlier large quadrats show considerably lower moisture values than the later ones. Dammerman (1925, 1937) found that the low point in population of the litter fauna in the East Indies was reached in the dry season, and a peak occurred in the wet season. A more thorough study will be necessary, with collections made in the dry season, before one can say that there is a seasonal fluctuation and that the results obtained here are really a reflection of this fluctuation.

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It is impossible for one to be sufficiently familiar with all groups of animals to make accurate taxonomic determinations. In a problem such as this, one must call upon specialists in the various groups. I am very grateful to the following persons for their kindness in making the determinations:

L. H. Hyman, Platyhelminthes
J. R. Christie, Nematoda
J. P. Moore, Hirudinea
W. G. Van Name, Isopoda
W. J. Gertsch, Arachnida (except Acarina)
A. P. Jacot, Acarina
W. A. Hilton, Pauropoda, and Symphyla
R. V. Chamberlin, Chilopoda and Diplopoda
F. Silvestri, Thysanura
Alfred Emerson, Isoptera
J. D. Hood, Thysanoptera
Z. P. Metcalf, Homoptera
W. J. Gerhard, Hemiptera (Heteroptera)
A. B. Gurney, Orthoptera, Dermaptera and Trichoptera
C. H. Curran, Diptera
T. J. Daggy, Diptera larvae and Coleoptera larvae
P. J. Darlington, Carabidae
H. B. Leech, Hydrophilidae
C. H. Seevers, Staphylinidae
Orlando Park, Pselaphidae
R. L. Wenzel, Histeridae
W. S. Fisher, Silphidae and Endomychidae
H. S. Barber, Scaphidiidae, Lampyridae, Dascylidae, and Dryopidae
E. A. Chapin, Tenebrionidae, Scarabaeidae, Nitidulidae, and Coccinellidae
L. L. Buchanan, Curculionidae and Hydrophilidae
M. W. Blackman, Ipidae
C. F. W. Muesebeck, Hymenoptera
N. A. Weber, Formicidae

SUMMARY

Methods of collection used in this study are described. Two sizes of quadrat were used, eleven of them were one meter square and eighteen of them were twenty-five centimeters square.

The general habitat and the floor stratum are described.

An analysis of the environmental factors, especially rainfall, relative humidity, temperature, and soil is presented.

A check list of the animals found includes representatives of five phyla, twelve classes, and thirty-seven orders.

A systematic analysis of the various taxonomic groups is included.

Faunal percentages were computed for each order. The Acarina, Collembola, and Hymenoptera (Formicidae) make up 80.64 per cent of the animals on the small quadrats and 88.24 per cent of those on the large.

The percentage of occurrence for each order represented was calculated and the characteristic groups, based on occurrence on at least 70 per cent of the large or small quadrats or a large population density, are indicated.

Analysis of the population by the method of Raunkiaer resulted in typical curves for both the large and small quadrats, indicating that most of the species are not very numerous, only seven of them occurring on 80 per cent or more of the quadrats.

The large number of species is characteristic of tropical faunas; 289 species have been determined to date. There were 67 new species, 20 new genera, and one new family.

Based on the small quadrats there is an average population of 9,822 per square meter (40,000,000 per acre). For the large quadrats the figures were 3,803 per square meter (15,500,000 per acre). The highest value for a small quadrat was 19,472 per square meter (79,000,000 per acre) and for a large one, 13,923 per square meter (56,000,000 per acre). These figures are based on the results for manual collection of all groups except the Acarina and Collembola which were collected by the Berlese funnel as explained in the text.

The biomass, based on 67 per cent of the animals, was 15.53 grams of animal protoplasm per square meter (138 pounds per acre).

An Eltonian pyramid of numbers, based on the small quadrats is presented.

The only factors in the soil analysis which varied significantly were pH and potassium. The number of animals present does not seem to be correlated with the potassium content of the soil. There is a suggestion,

especially in the small quadrats, that high population values are associated with a neutral pH. There is some correlation between soil moisture and population density.

Within certain limits the amount of leaf mold does not directly control the number of organisms, but very high and very low amounts do act as controlling factors.

Army ants were the only predator factor that could be correlated directly with the population density. In two cases where army ants had raided in an area on the day preceding collection, the population density was very low.

During the day there was no apparent correlation between time of collection and number of animals.

Two quadrats collected at night gave very low values for the population density. It may be that there is a nocturnal fluctuation in population due to migration into higher strata or into the soil.

There was a gradual increase in population density during the month of July. It is suggested that there is a seasonal change in population density with a low density in the dry season. Collections made early in the rainy season show a gradual rise in population correlated with the onset of the rains.

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